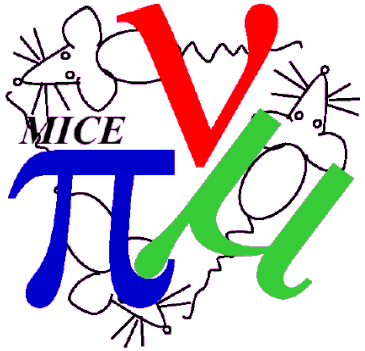
Fermilab



MICE Spectrometer systems

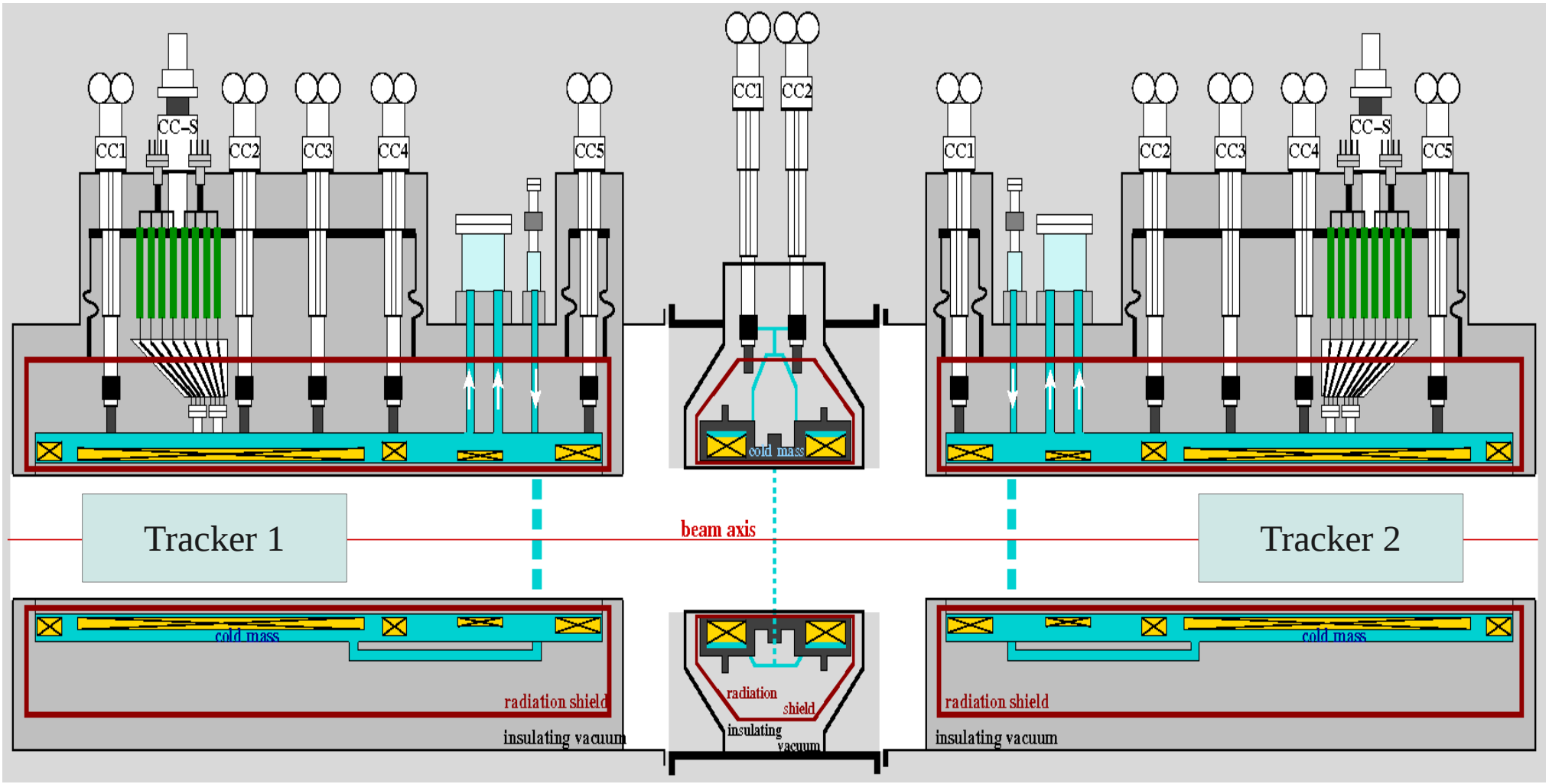
D Adey

MAP Winter Meeting
SLAC
6th December 2014

adey@fnal.gov

Content

- Spectrometer solenoid installation in MICE hall
- Tracker infrastructure QA and preparation
- November installation and LED/Readout testing
- Software progress
- Commissioning and run plans/needs
- Analysis preparation



- Trackers placed with 4T solenoidal field
- End and matching coils for uniformity and matching lattice with focus coil
- Allows single particle measurement
- Aim 0.1% measurement of emittance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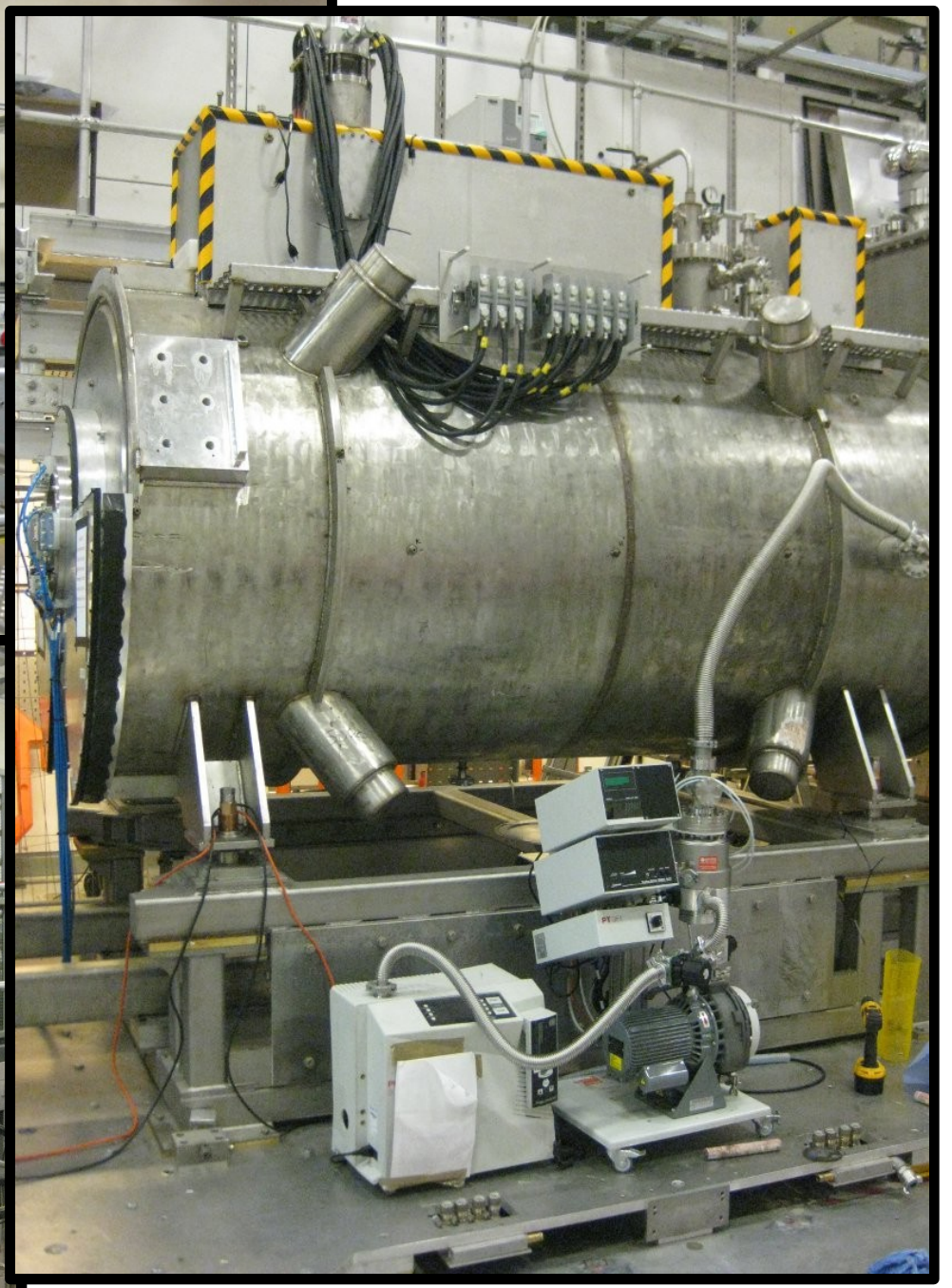
Danger

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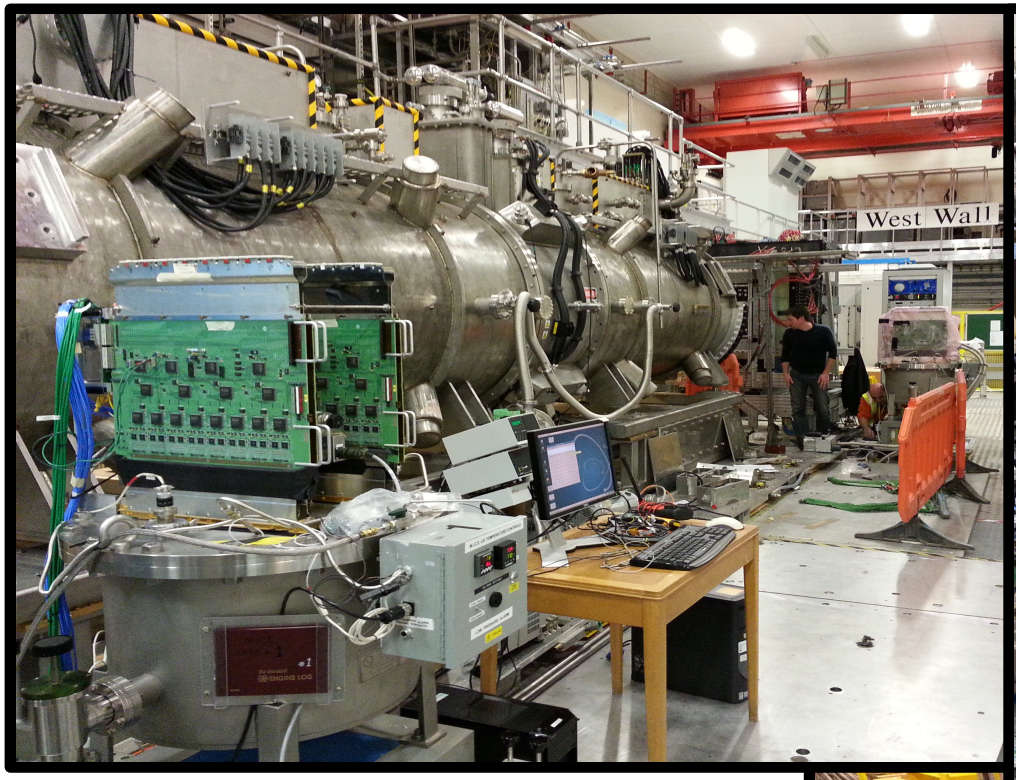
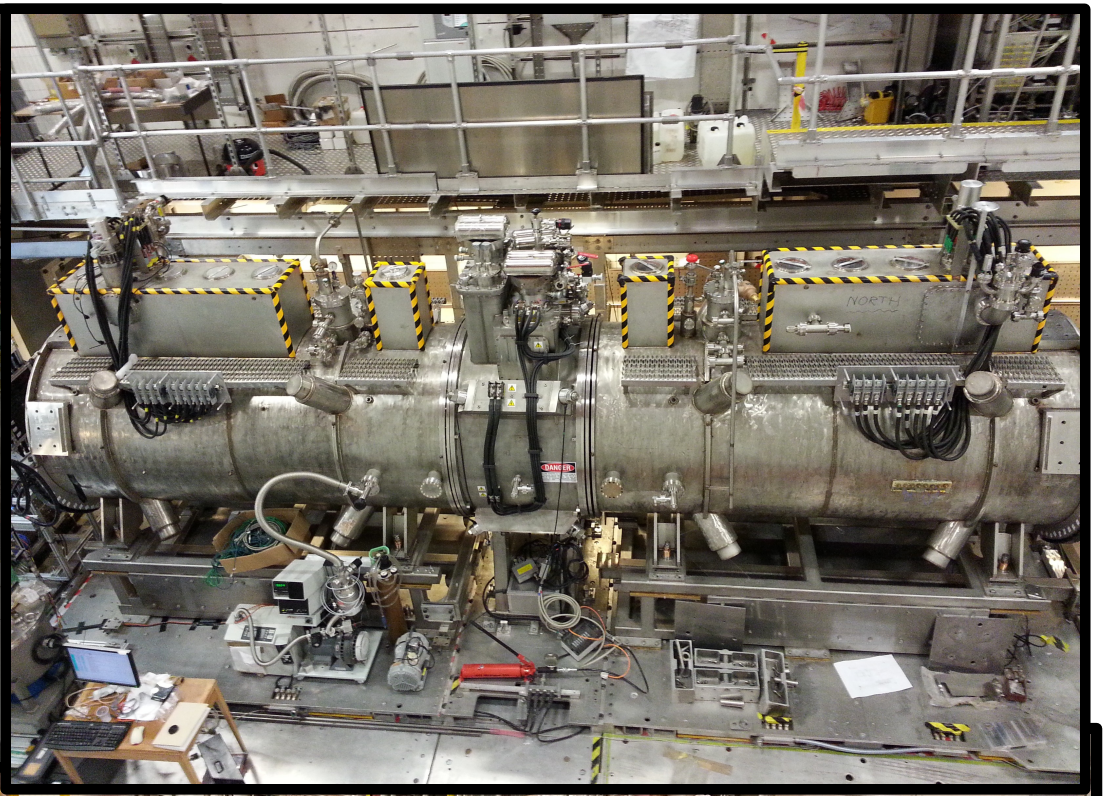
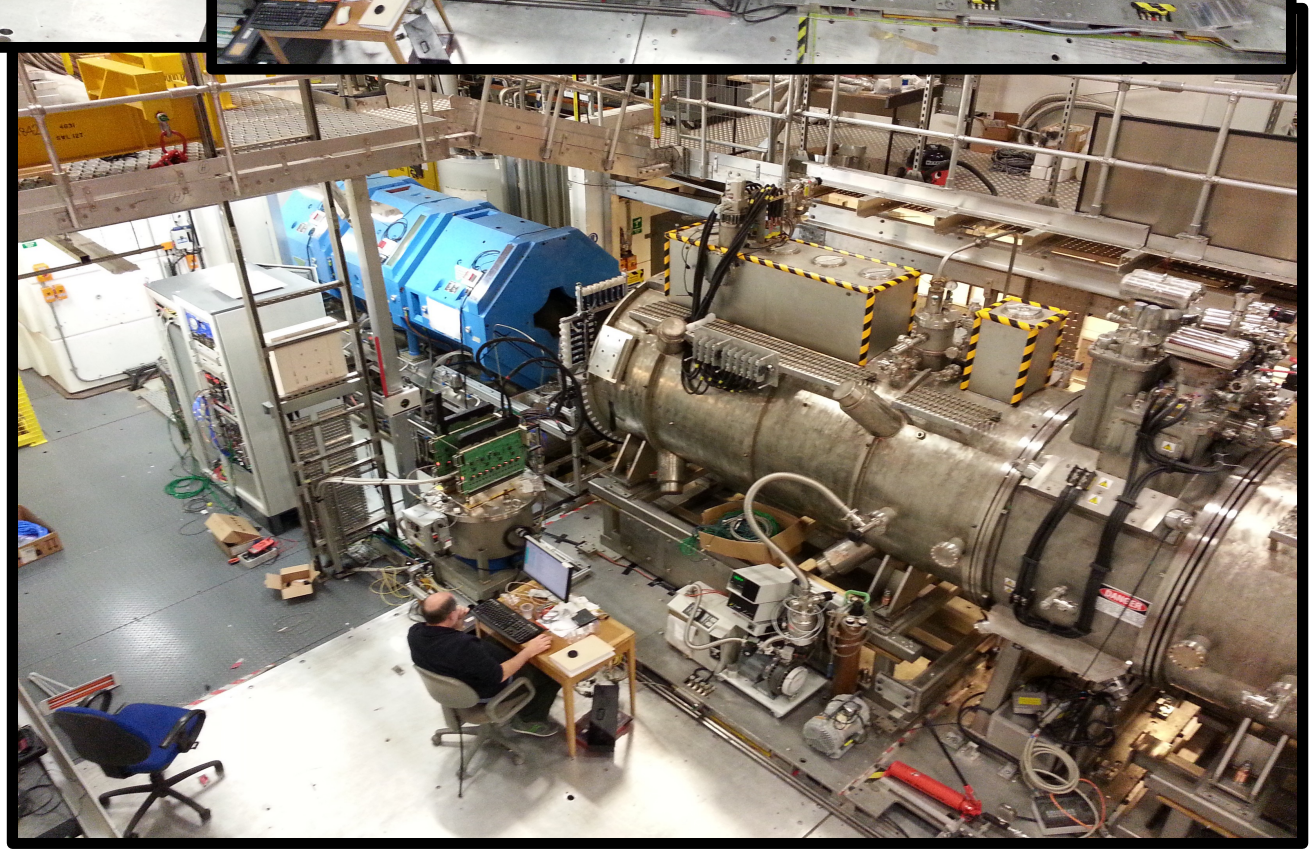




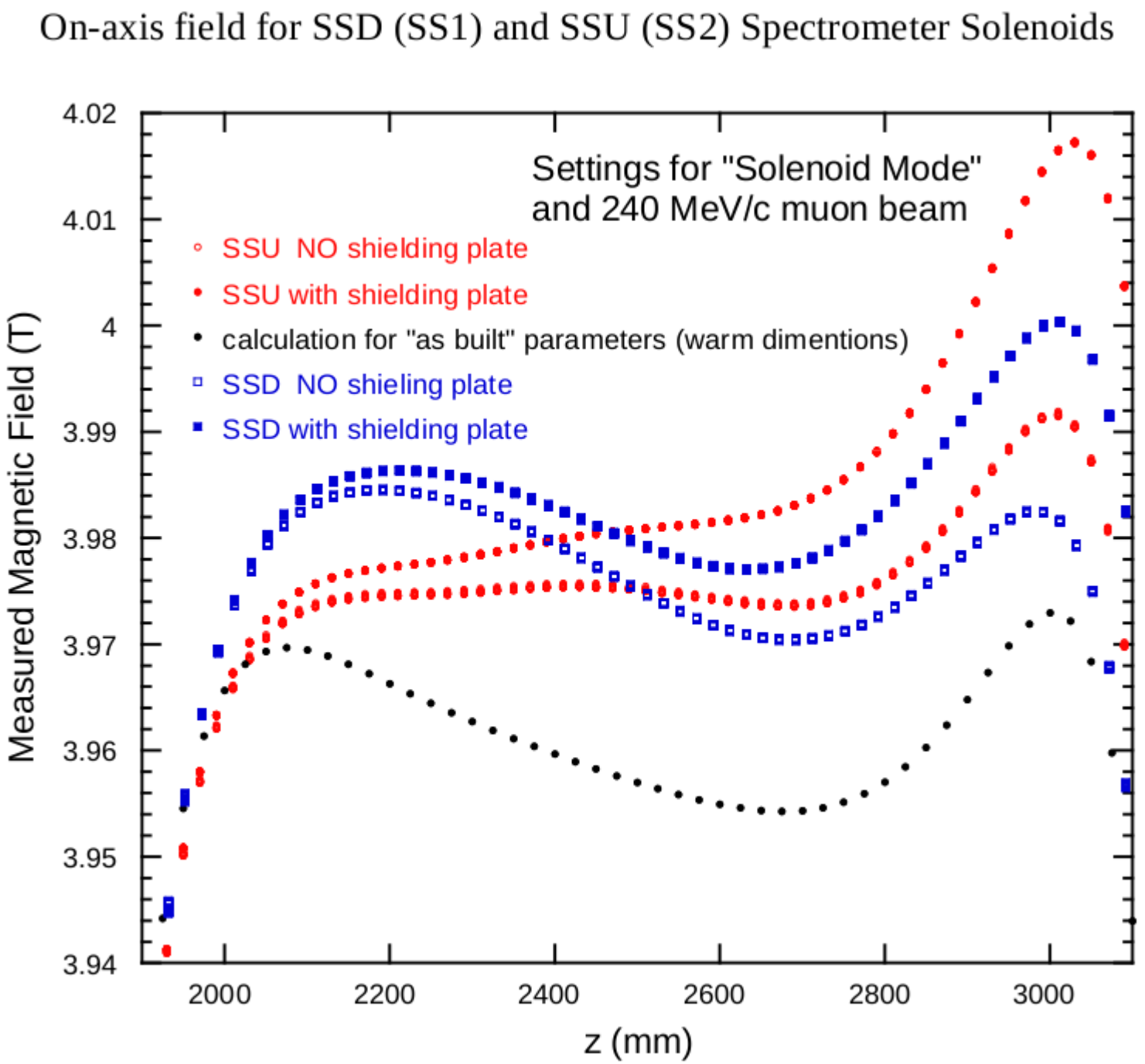
- Spectrometers (with trackers already installed) moved into hall with focus coil and tracker readout cryostats
- HTS connections and vacuum systems setup
- Vacuum leak attributed to ceramic feed-through
- Modifications to quench protection voltage taps
- Cryocoolers to be installed Feb 15



Field mapping and fitting

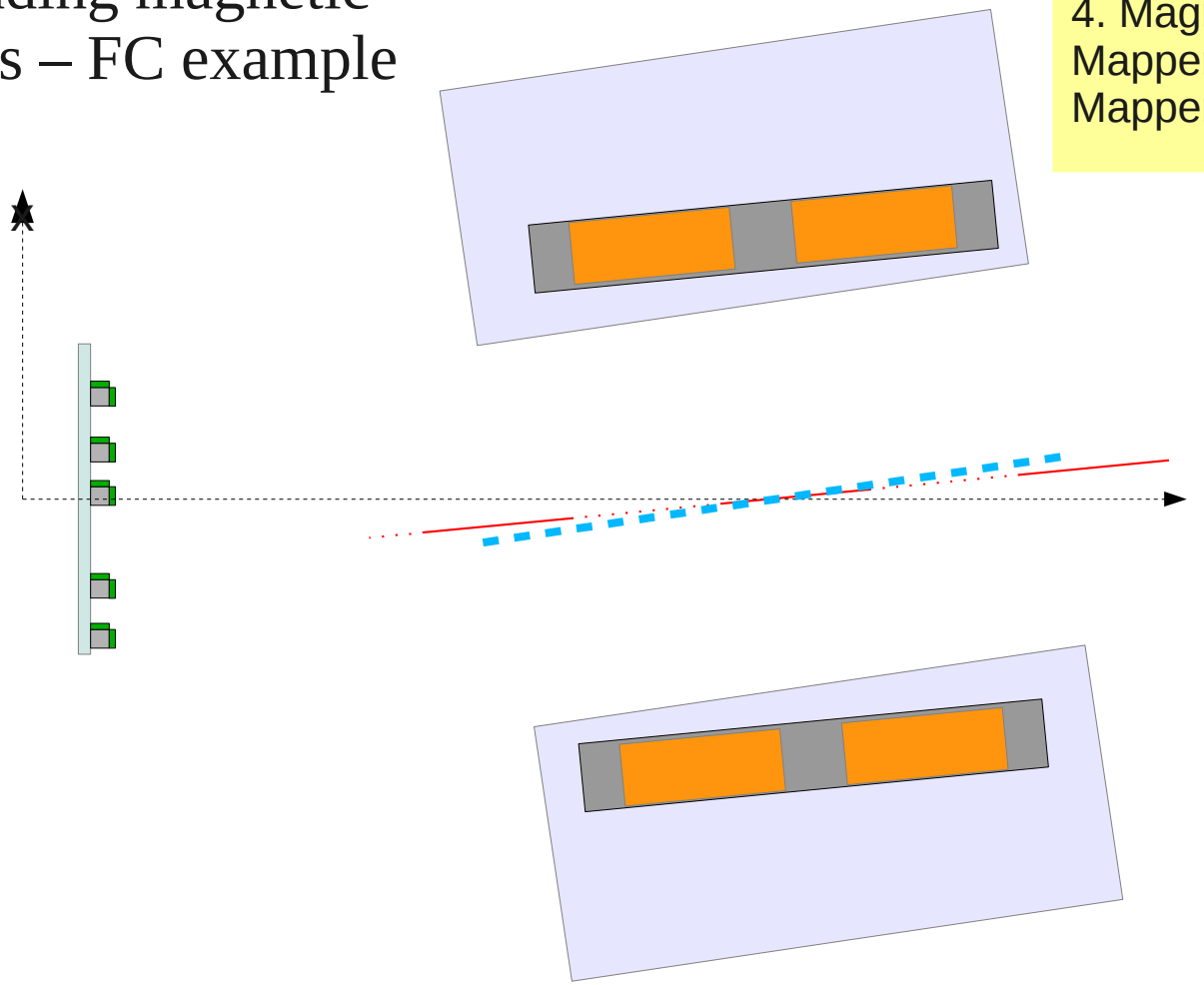
- Need to align the magnetic axis to the beam axis
- Need to know the field map within the tracker for momentum reconstruction
- Maps of both solenoids in operating modes, including single coil measurements, made at vendor (see M. Leonova talk from Spring MAP meeting)

Preliminary B_z – no alignment fitting

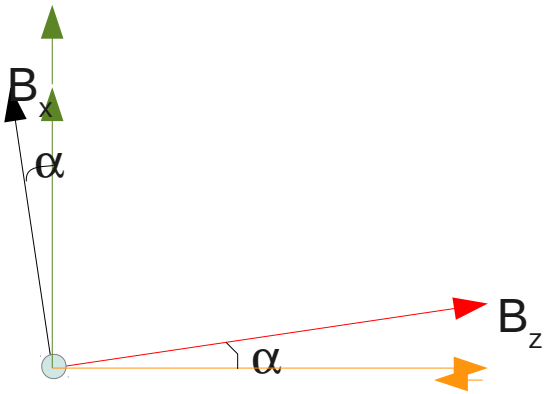


Finding magnetic axis – FC example

4. Magnetic & geometric axes not aligned.
Mapper not aligned to geometric axis.
Mapper not aligned to magnetic axis.



$B_{xm} = B_x \cos(\alpha) + B_z \sin(\alpha)$



$Bz_m = B_z \cos(\alpha) - B_x \sin(\alpha)$

Angles are small:

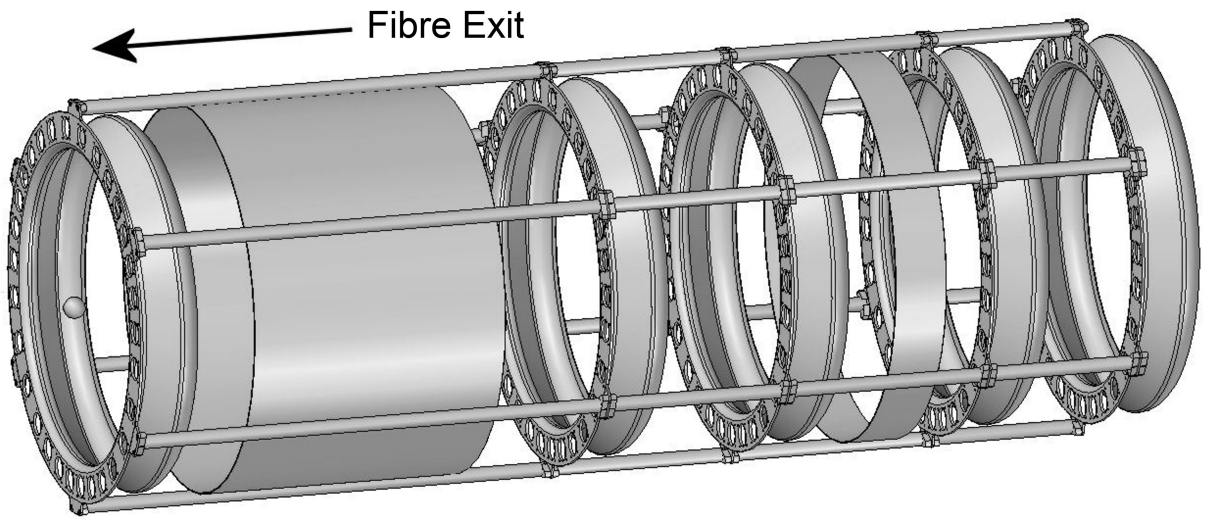
1) $B_{xm} \tilde{z} B_x + \alpha B_z$ and

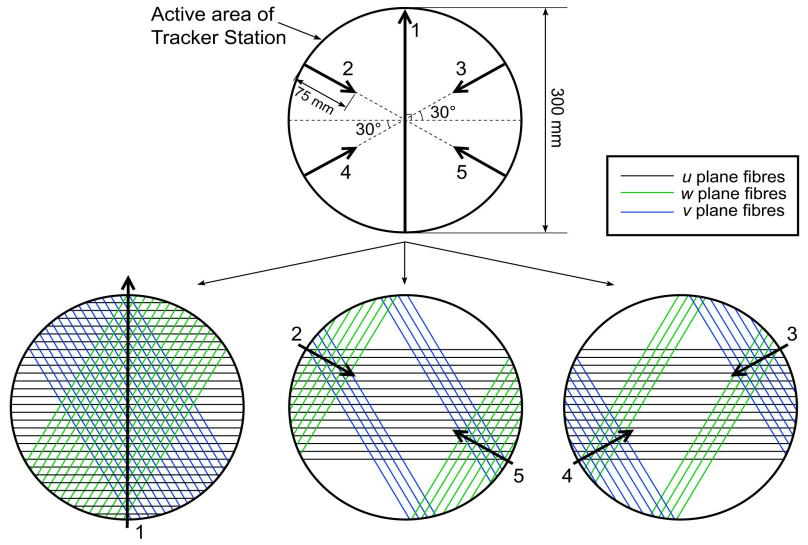
2) $B_{zm} \sim B_z + \alpha B_x$

B_z is large:

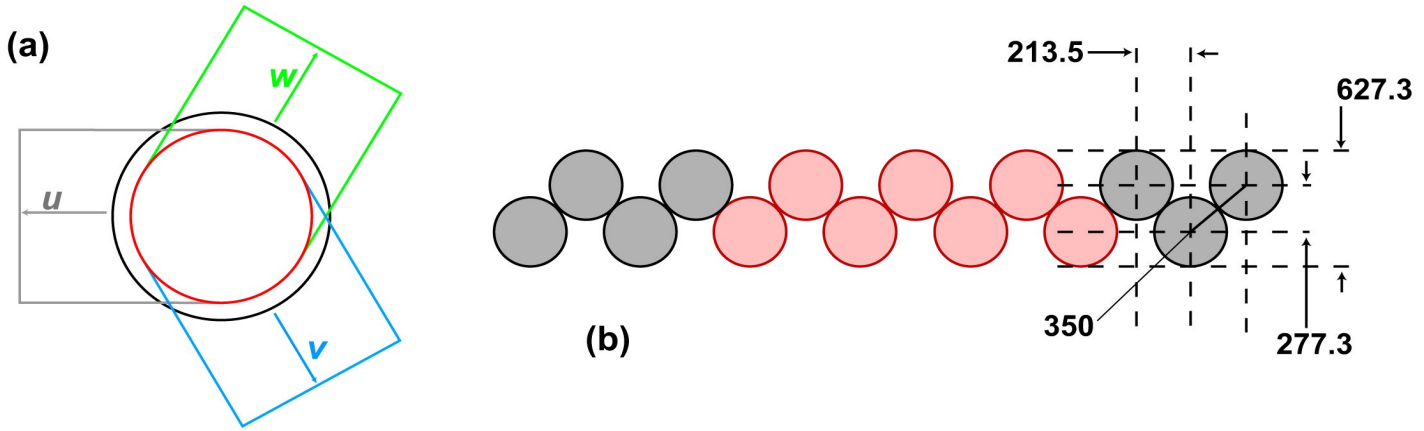
1) $B_{xm} \sim B_x + \alpha B_z$

2) $B_{zm} \sim B_z$

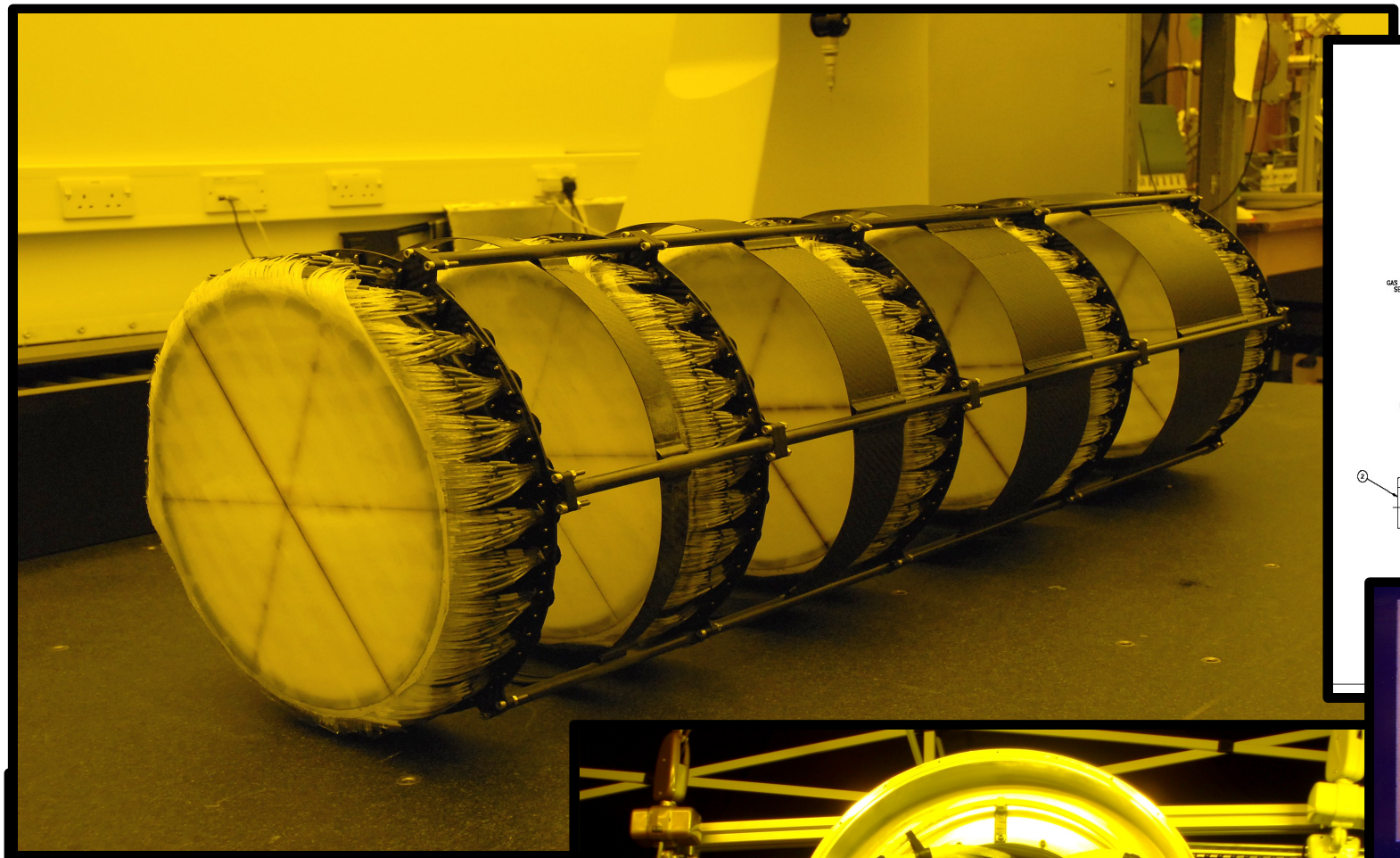


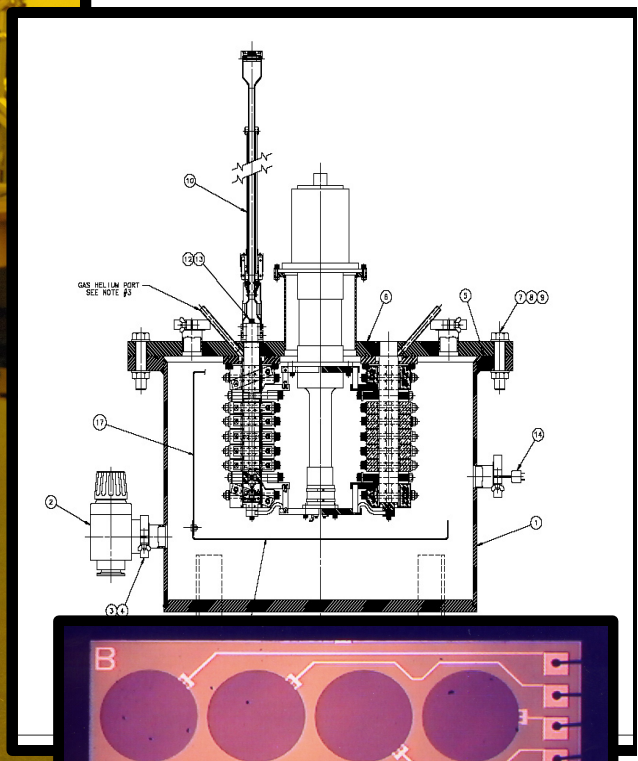


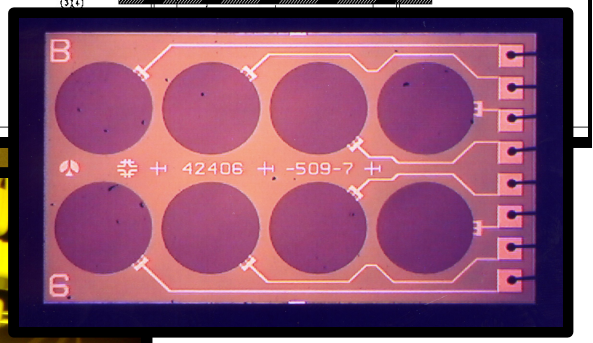
Station 5 | Station 4 | Station 3 | Station 2 | Station 1



- 5 measurement “stations”
- 3 fiber planes per station at 120 degrees
- 350micron fibers grouped into ~214 channels per plane, generating a mean of 10PE/MIP
- Intrinsic position resolution of 470 microns
- Photo-detection with VLPC – cryogenic operated photodetectors
- Readout with D0 analogue front end
- Total ~6000 fiber channels from ~8000 readout channels




GAS HELIUM PORT
SEE NOTE #3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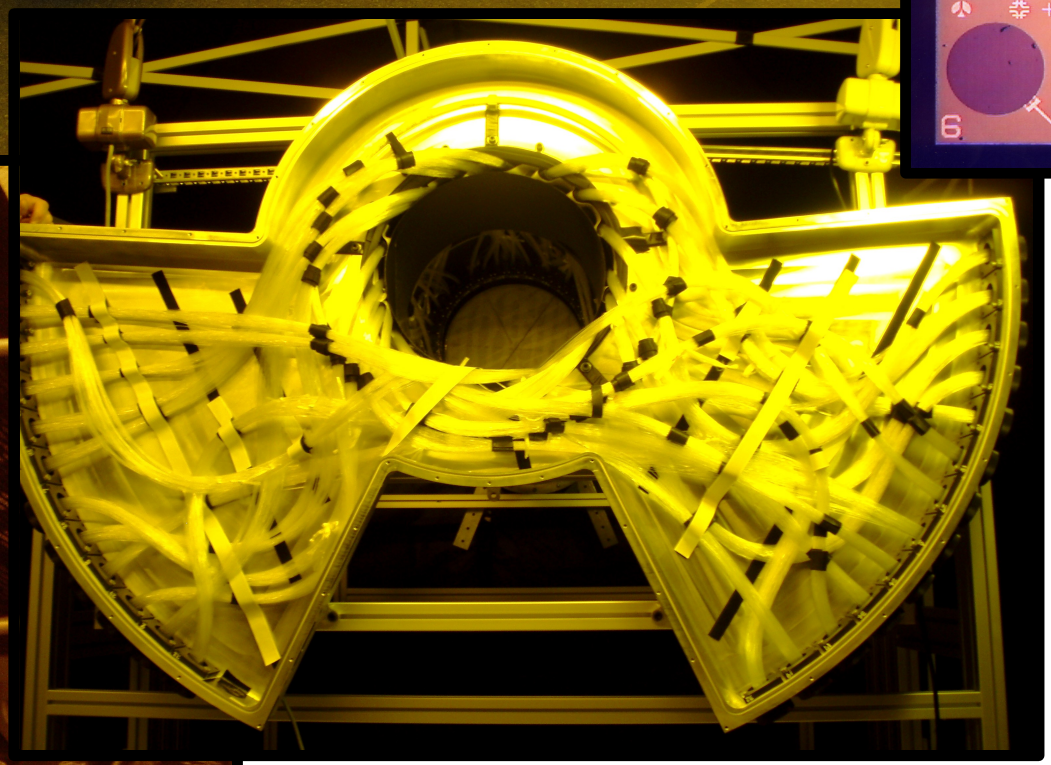
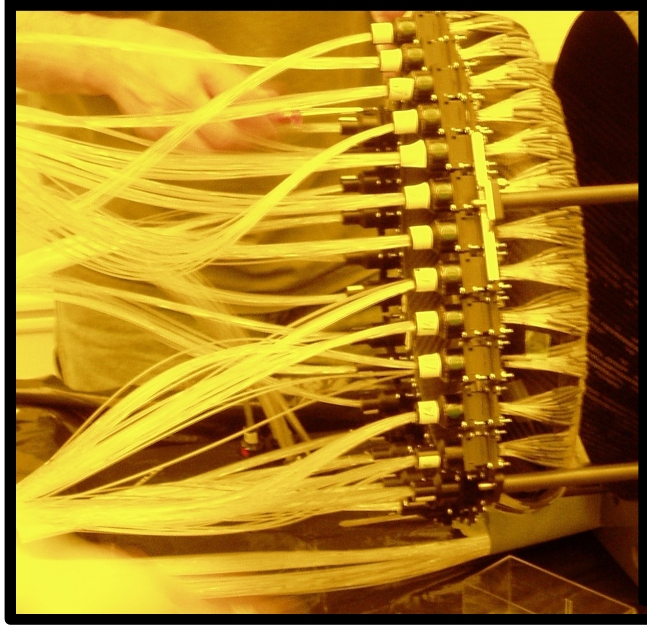




September equipment tests

- Check Wiener power supplies – one faulty repaired by vendor, spare ordered
- Vacuum turbo pumps idle for >1 year, but inspected by vendor
- Readout electronics full QA, not-insignificant selection of bad chips discovered (brok TriPt, FPGA) – full set of spares (16 AFE boards) removed from D0 in addition to 8 spares at RAL
- Other spares (VME buffers, bayonets) also found/acquired

November installation and tests

- All four cryostats installed

- Vacuum pump-down mostly successful, some variations between cryostats but at specification

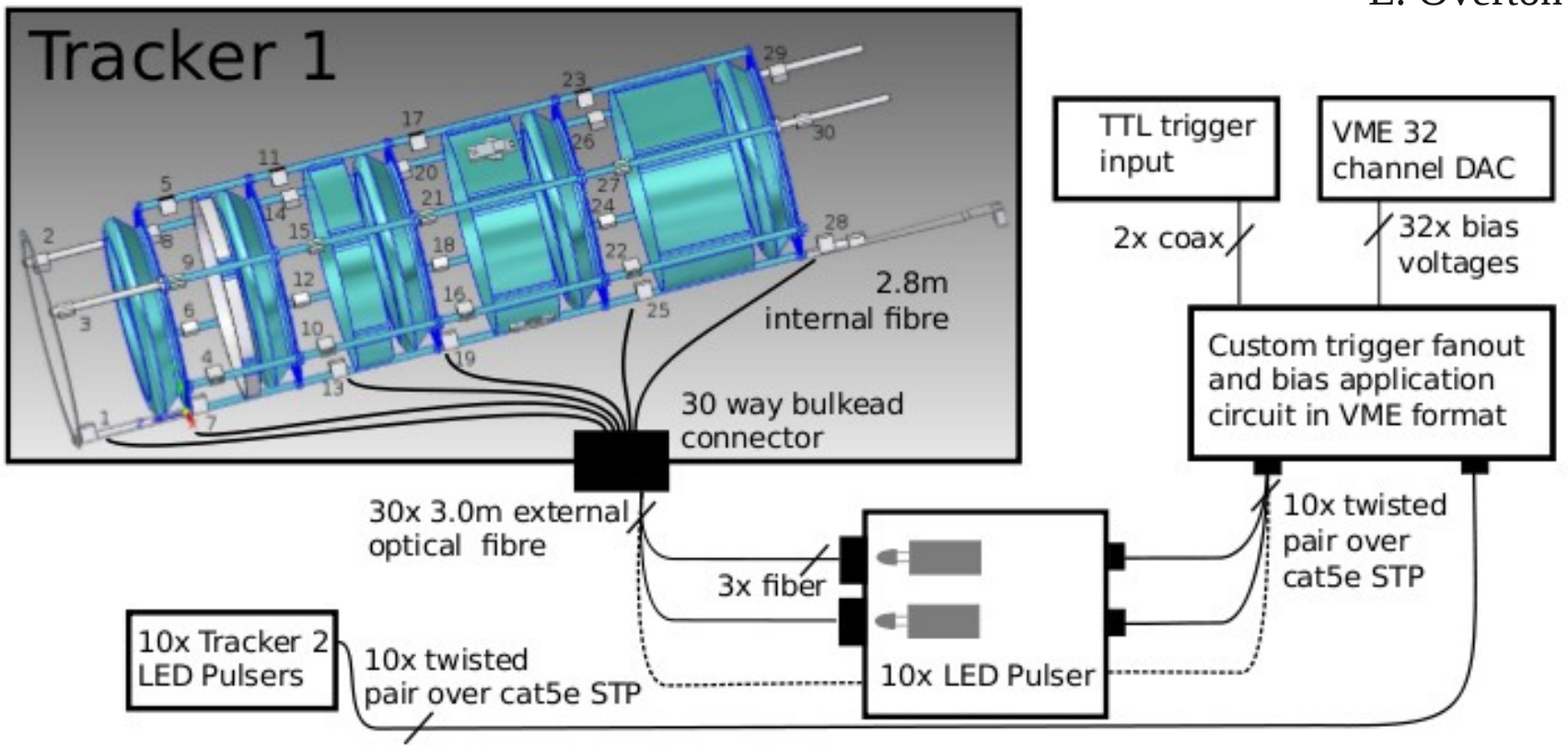
- Compressors installed in original magnetic field mitigation locations – 20-30m hoses to cryocoolers

- Plan – verify cooldown and performance of VLPCs; integrate new trigger logic; install and inspect internal LED; update and replace with D0 spares

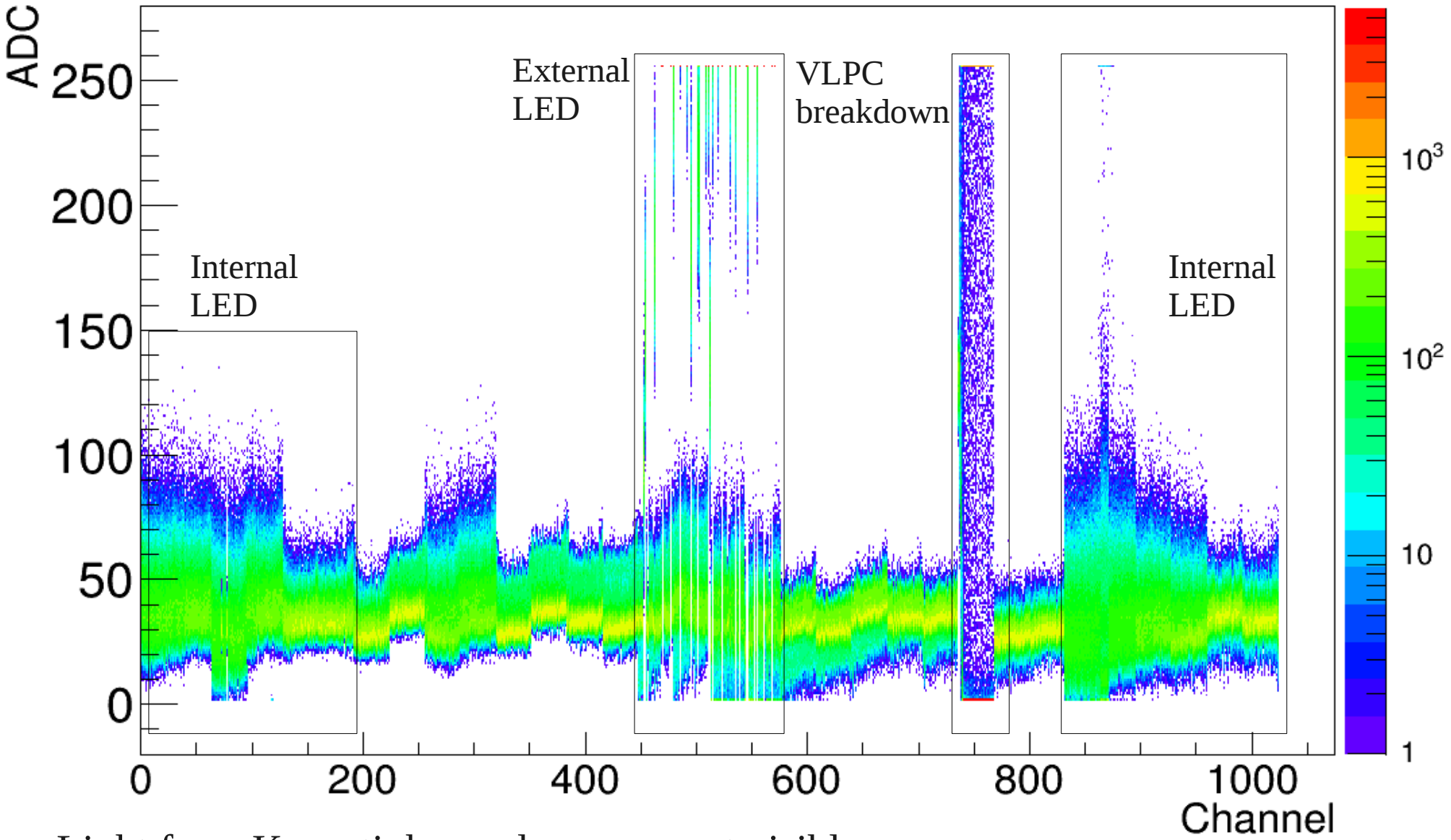
"In every adversity of fortune, to have been happy is the most unhappy kind of misfortune" - Boethius, Consolation of Philosophy

- The test did not go as productively as previous tests
- Temperature monitoring and control units failed/lost calibration/behaved randomly
- Essential computer hardware failed
- Cryostats failed to reach design temperature of ~6K – temperature at VLPCs measured as 9.5-10.5K
- Upstream cryostats (with untested 30m hoses) ~1K warmer than (used) downstream 20m hoses
- Hoses alone would not explain temperature rise
- High temperature made VLPCs very noisy and

E. Overton

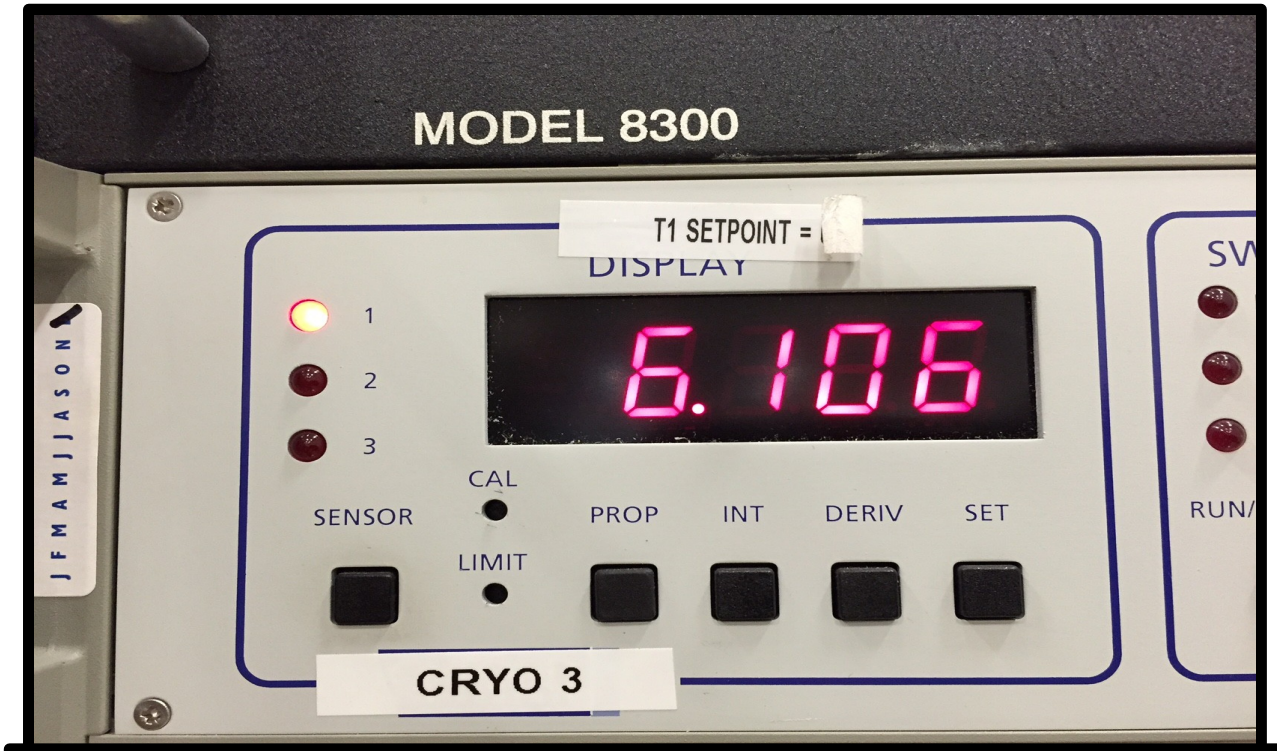


- Drive Kapustinsky pulser externally to tracker and feed fibers though spare waveguide connector
- Illuminate 3 fiber-LEDs on each face of each of the 5 tracker stations
- High T/noise conditions of VLPC made observing signal difficult
- Output of fibers at connection to tracker visible by eye

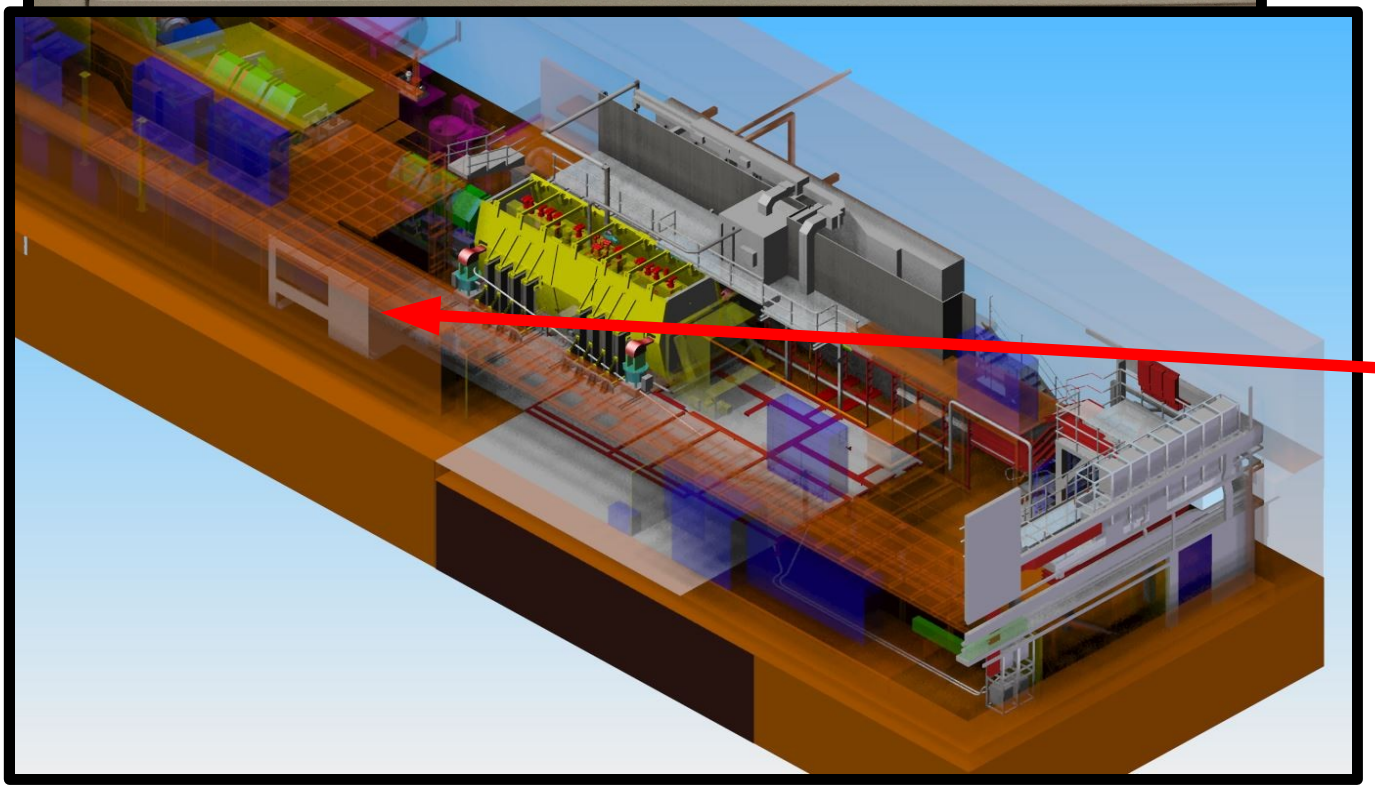


- Light from Kapustinksy pulsers was not visible
- Longer pulse LED applied to internal fibers was visible, but obscured by noise from high temperature (over biased) environment
- Issue with system probably lies in limited pulse length (2.5ns) – modifications may mitigate problem

C. Macwaters



"After only 1.5 days the new cleaned out cold head for compressor 3 has the cryostat down to T1=6.1K. This is nearly 1K lower than it originally achieved after running a week."



With PRY compressors no-longer need to be so far from cryostats

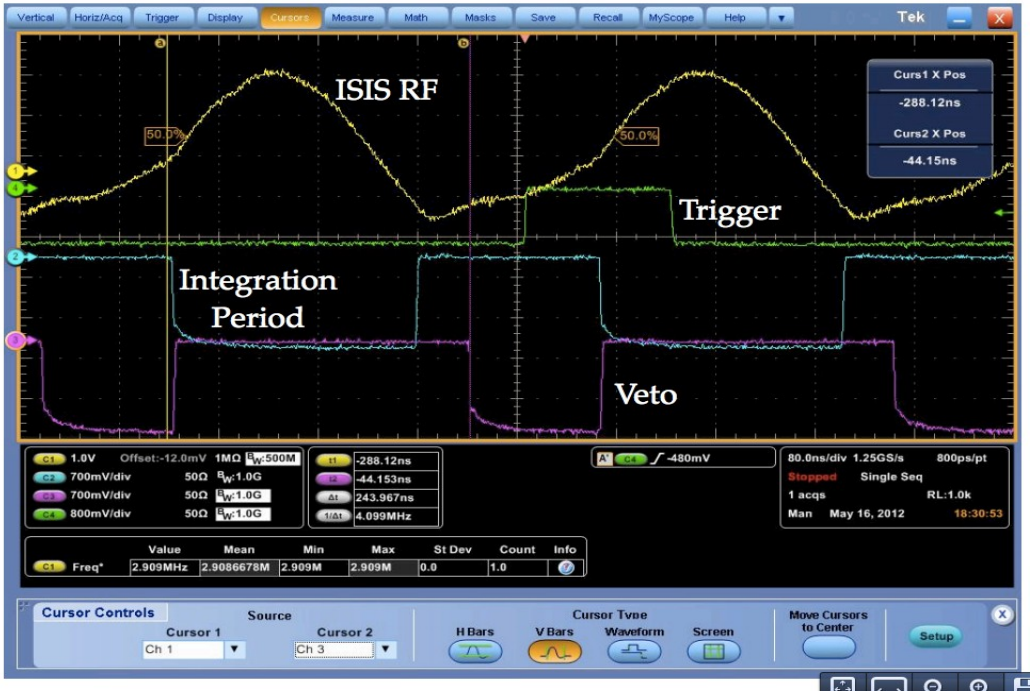
Movement of upstream compressors into trench – reduce hose length

Commissioning

- Everything must work – cryo/vacuum systems, readout electronics, power supplies, waveguides, LEDs, software for as installed trackers
- Integrate with final trigger/DAQ systems – Jan 15
- Ensure timing with ISIS 3MHz RF cycle is understood at an acceptable level (aim for 0.01%) - First beam (April 15?)
- Understand relative efficiency of each tracker – First beam
- Know the alignment of trackers in the global coordinate system – First beam with and without field
- Mock data run in January is goal for integration. Alignment and other commissioning will require beam

Observe all expected tracks

- Points/trigger (veto period) LY/point or TDC (int. period)
- Large statistics measurement of hit efficiency and MIP light yield, necessitating LED + beam
- Expectation of solenoid acceptance in each mode / TOF1 acceptance



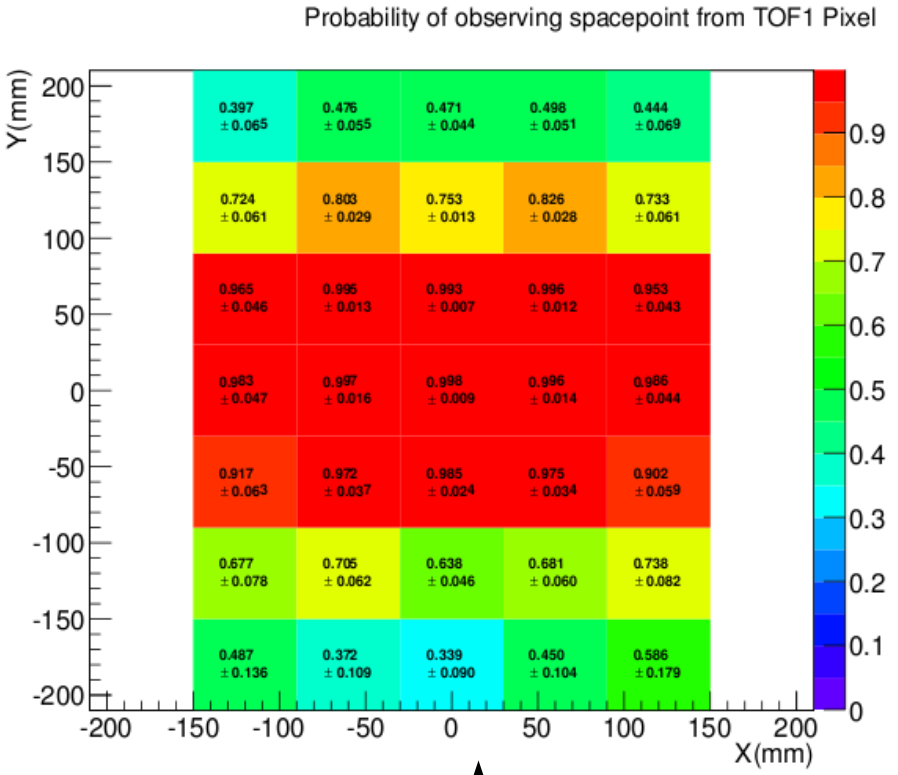


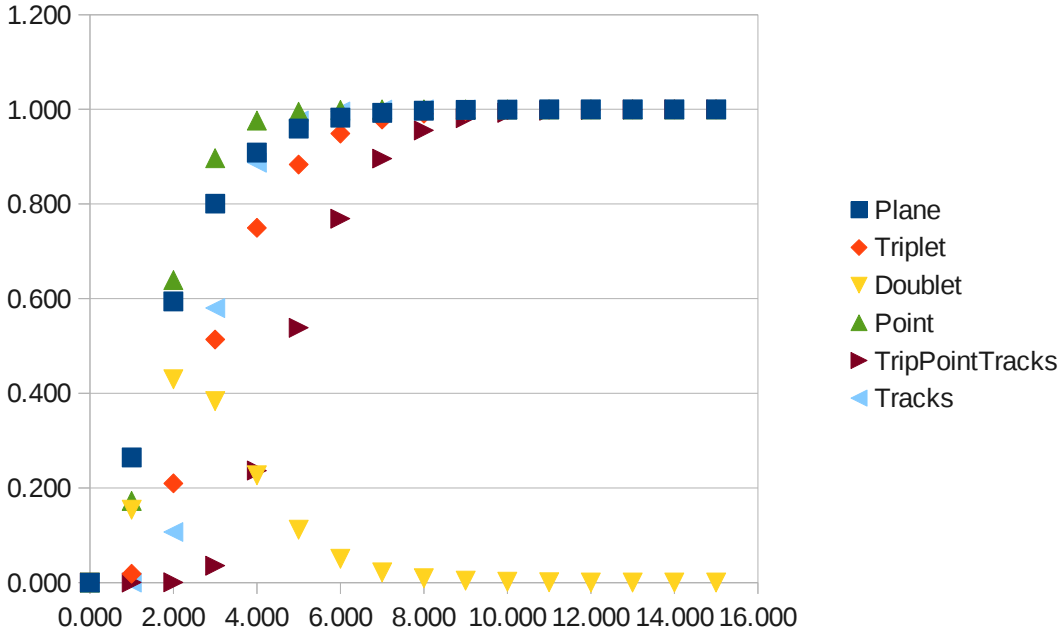
Figure 11: Space-point finding [illegible]cy for each pixel in TOF1

Step I

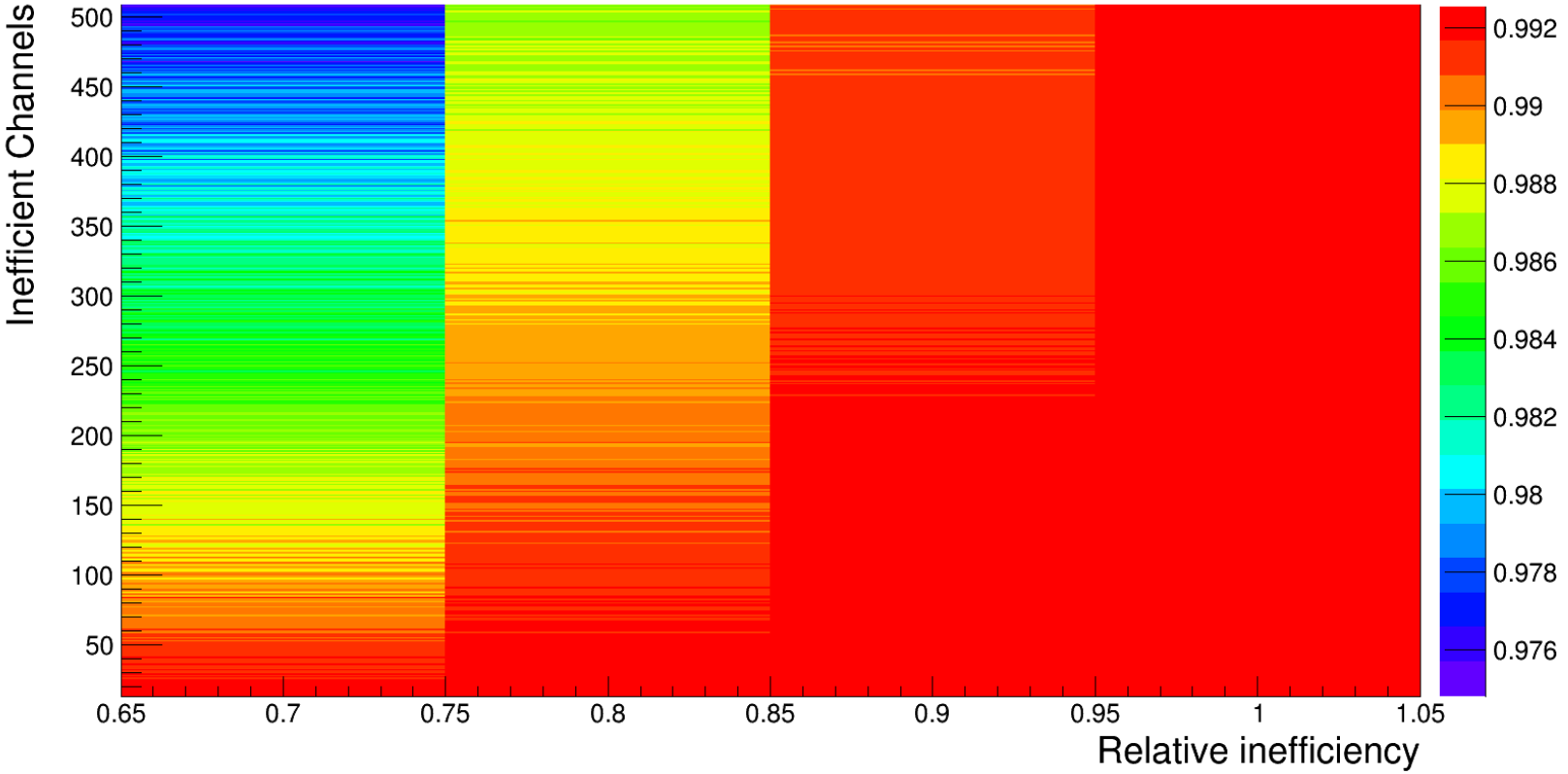
Table 3 The characterised Step I beams

	Beam ε_N	Beam p_z	$\langle p_z \rangle$ (MeV/c)	σ_{pz} (MeV/c)	ε_x (π mm-rad)	α_x	β_x (m)	ε_y (π mm-rad)	α_y	β_y (m)
μ^-	3	140	171.58 ± 2.39	22.81 ± 0.32	2.28 ± 0.12	0.50 ± 0.01	1.49 ± 0.09	0.95 ± 0.05	-0.55 ± 0.28	3.62 ± 0.18
		200	223.24 ± 2.72	24.02 ± 0.29	1.74 ± 0.09	0.49 ± 0.01	1.69 ± 0.10	0.78 ± 0.04	-0.50 ± 0.25	3.71 ± 0.19
		240	260.55 ± 3.24	24.49 ± 0.30	1.49 ± 0.08	0.49 ± 0.01	1.80 ± 0.10	0.75 ± 0.04	-0.41 ± 0.21	3.65 ± 0.18
	6	140	176.43 ± 2.27	22.83 ± 0.29	2.17 ± 0.12	0.52 ± 0.01	1.57 ± 0.09	0.96 ± 0.05	-0.54 ± 0.28	3.64 ± 0.18
		200	232.22 ± 2.51	23.62 ± 0.26	1.53 ± 0.08	0.55 ± 0.01	1.85 ± 0.10	0.78 ± 0.04	-0.51 ± 0.26	3.80 ± 0.19
		240	270.96 ± 3.65	24.53 ± 0.33	1.51 ± 0.08	0.48 ± 0.01	1.80 ± 0.10	0.73 ± 0.04	-0.39 ± 0.20	3.51 ± 0.18
	10	140	183.46 ± 2.35	22.75 ± 0.29	2.01 ± 0.11	0.53 ± 0.01	1.62 ± 0.09	0.92 ± 0.05	-0.56 ± 0.29	3.68 ± 0.18
		200	247.23 ± 3.56	24.20 ± 0.35	1.23 ± 0.07	0.59 ± 0.01	2.22 ± 0.13	0.75 ± 0.04	-0.52 ± 0.27	3.81 ± 0.19
		240	281.89 ± 3.65	25.28 ± 0.33	1.65 ± 0.09	0.56 ± 0.01	1.82 ± 0.10	0.64 ± 0.03	-0.39 ± 0.20	3.40 ± 0.17
μ^+	3	200	222.69 ± 2.40	26.49 ± 0.29	1.98 ± 0.11	0.49 ± 0.01	1.58 ± 0.09	0.83 ± 0.04	-0.40 ± 0.20	3.44 ± 0.17
		240	257.97 ± 2.83	26.37 ± 0.29	1.59 ± 0.08	0.57 ± 0.01	1.87 ± 0.11	0.76 ± 0.04	-0.31 ± 0.16	3.40 ± 0.17
	6	140	176.45 ± 1.98	24.36 ± 0.27	2.32 ± 0.12	0.45 ± 0.01	1.50 ± 0.09	0.95 ± 0.05	-0.48 ± 0.25	3.59 ± 0.18
		200	229.16 ± 2.36	25.87 ± 0.27	1.91 ± 0.10	0.50 ± 0.01	1.61 ± 0.09	0.81 ± 0.04	-0.38 ± 0.19	3.42 ± 0.17
		240	267.65 ± 2.85	25.79 ± 0.28	1.69 ± 0.09	0.54 ± 0.01	1.76 ± 0.10	0.76 ± 0.04	-0.26 ± 0.14	3.23 ± 0.16
	10	140	182.42 ± 2.05	23.87 ± 0.27	2.16 ± 0.12	0.47 ± 0.01	1.56 ± 0.09	0.92 ± 0.05	-0.48 ± 0.24	3.59 ± 0.18
		200	243.39 ± 2.65	26.77 ± 0.29	1.66 ± 0.09	0.51 ± 0.01	1.78 ± 0.10	0.78 ± 0.04	-0.38 ± 0.19	3.37 ± 0.17
		240	274.77 ± 2.94	24.79 ± 0.27	1.78 ± 0.09	0.51 ± 0.01	1.65 ± 0.09	0.76 ± 0.04	-0.22 ± 0.11	3.07 ± 0.15

Efficiency

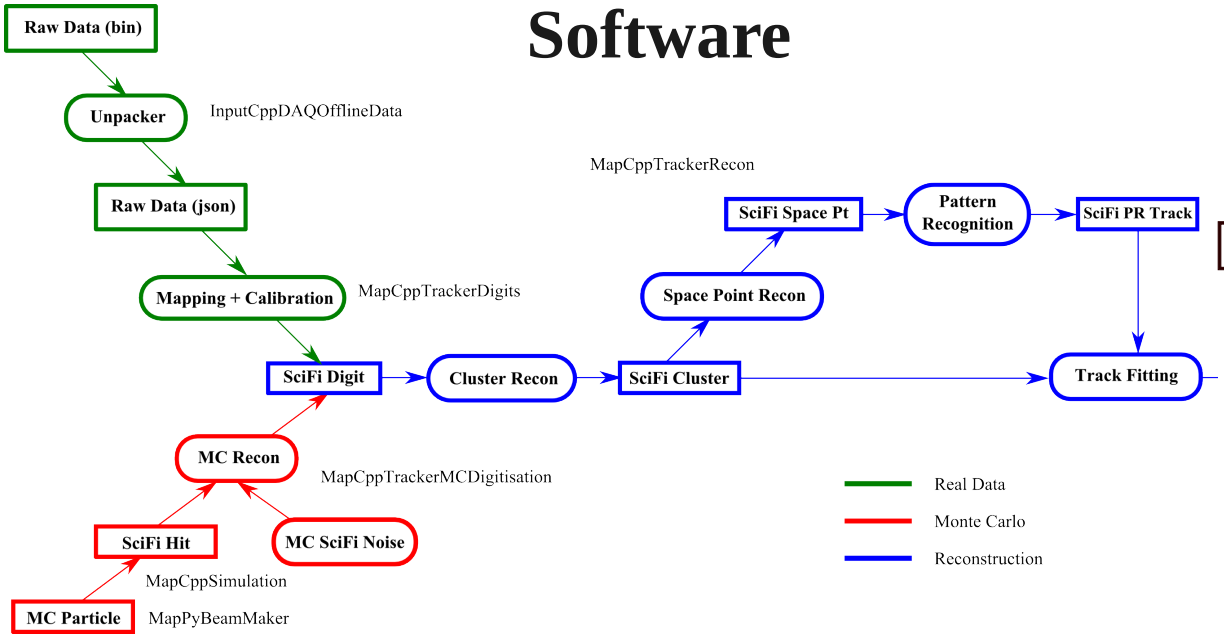


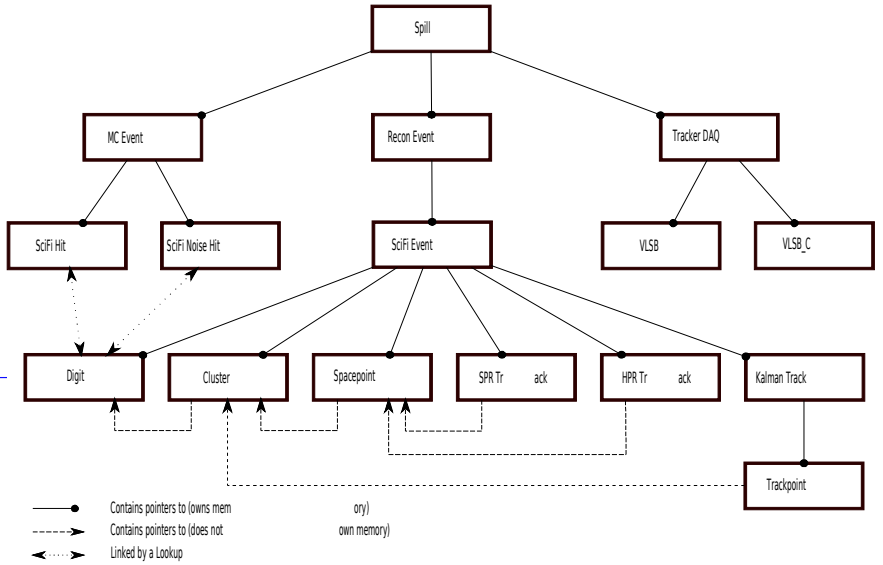
- Unexpected loss in efficiency is not critical problem for trackers (high light yield, degeneracy in channels)
- Important to understand for analysis of transmission etc.
- Combination of beam and internal LED

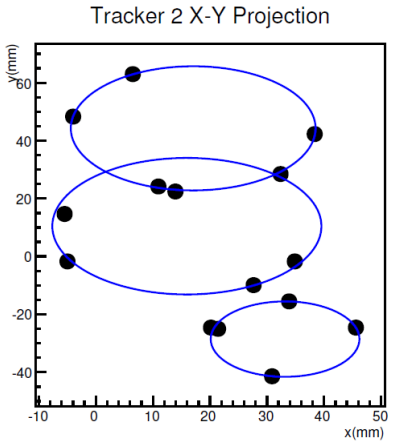


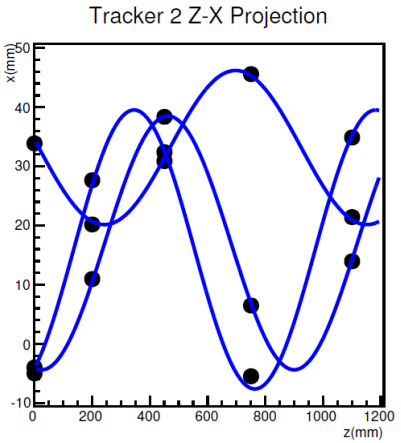
Five point triplet tracks

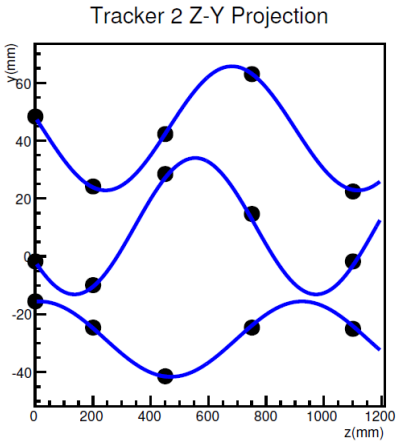
Software





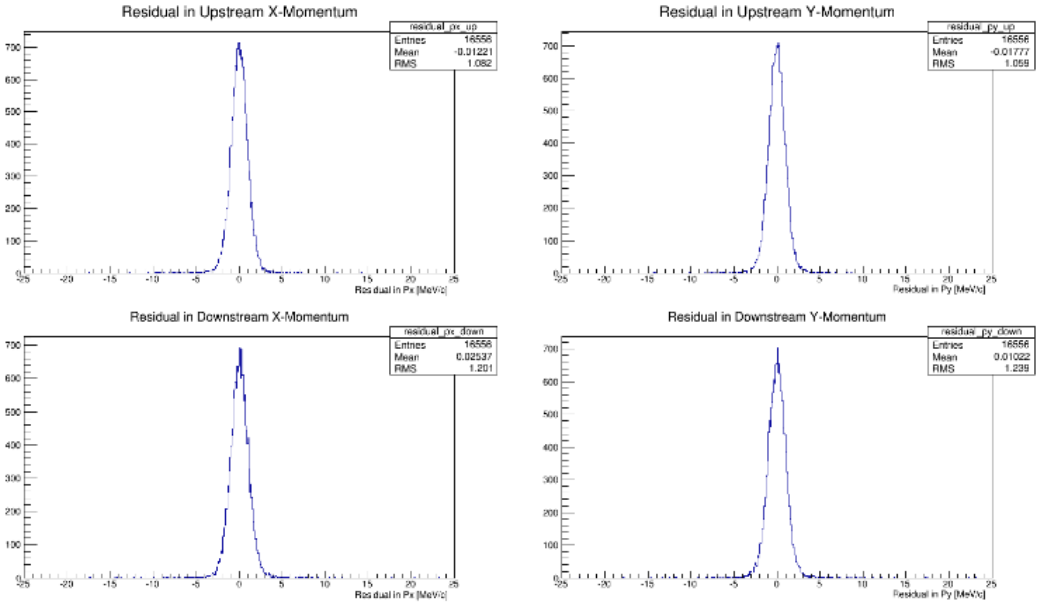


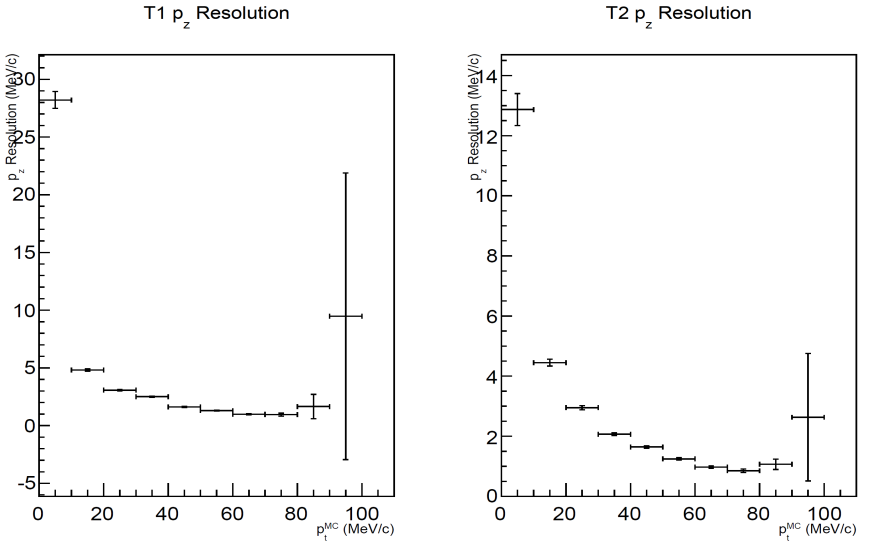




- Tracker simulation and reconstruction software framework largely complete and performance analyzed
- Work remains on detector modelling (to match the as-installed performance) and track filtering
- Response to any non-uniformities or mis-alignments of the magnetic fields are a priority

X & Y Momenta

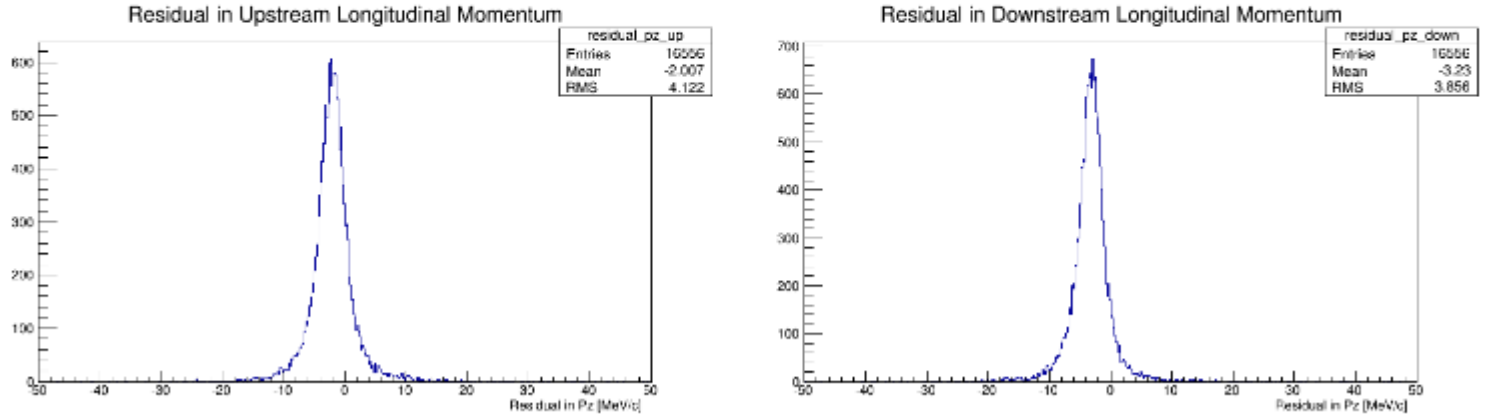




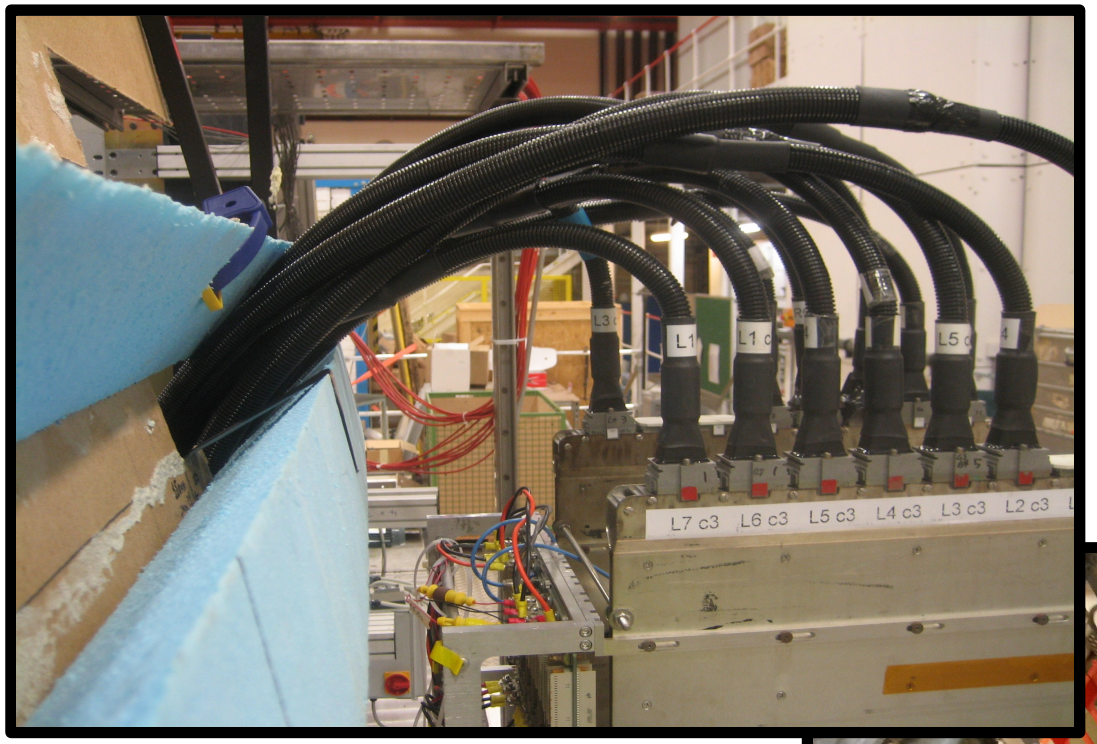
All Mean ≈ 0.0, RMS ≈ 1.2 MeV/c

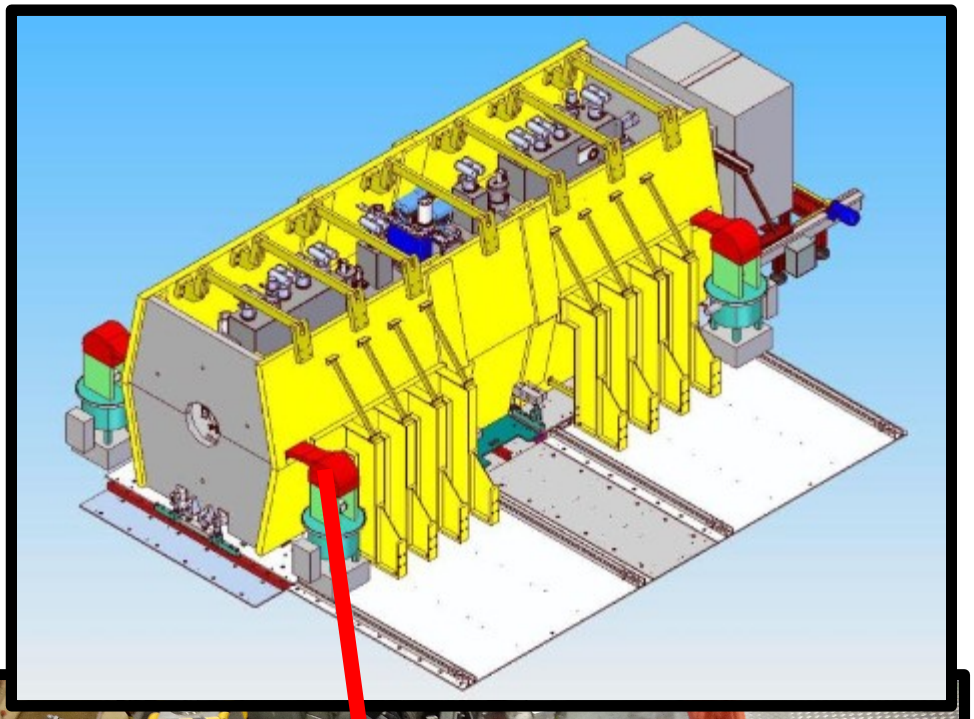
Upstream Mean = -2.0 MeV/c Downstream Mean = -3.9 MeV/c

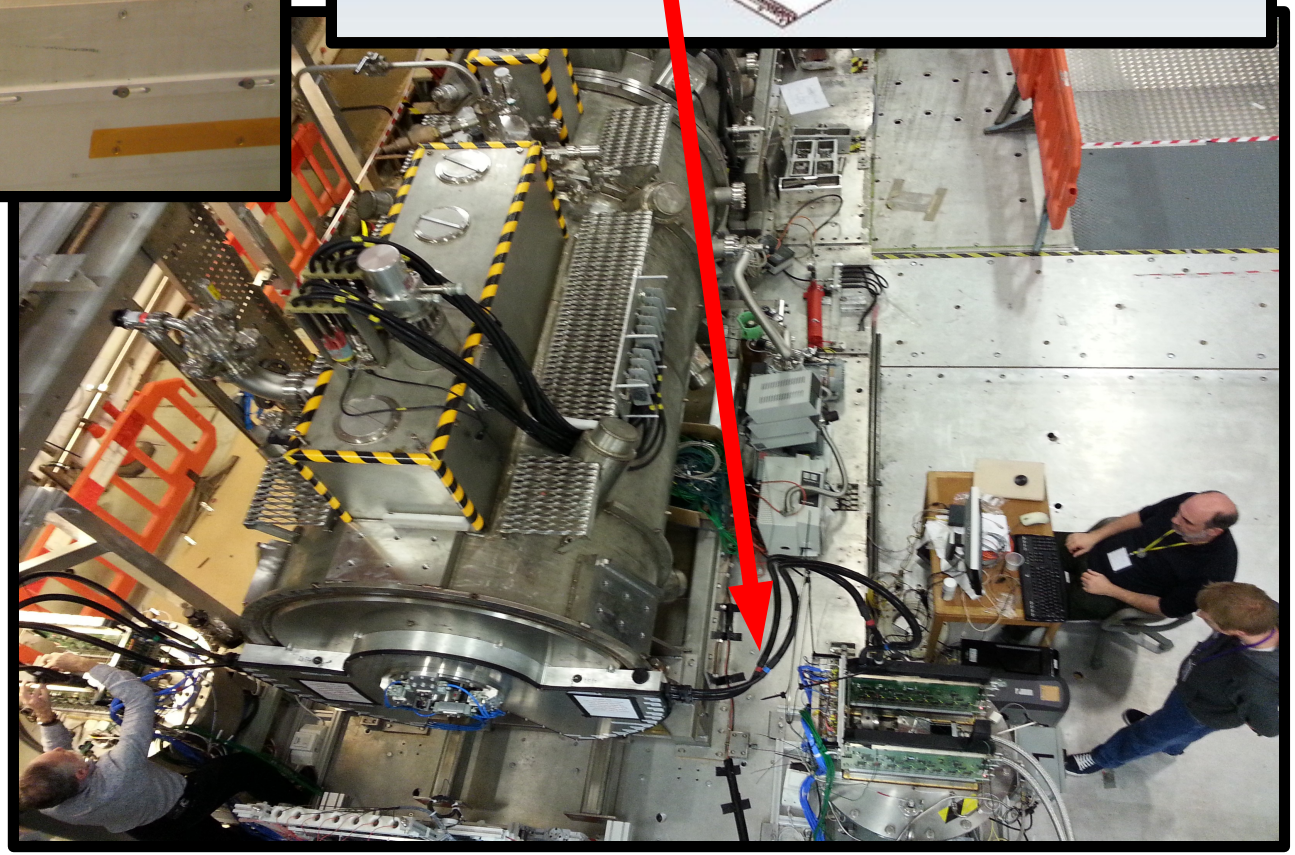
Both RMS ≈ 4.0 MeV/c



PRY and trackers

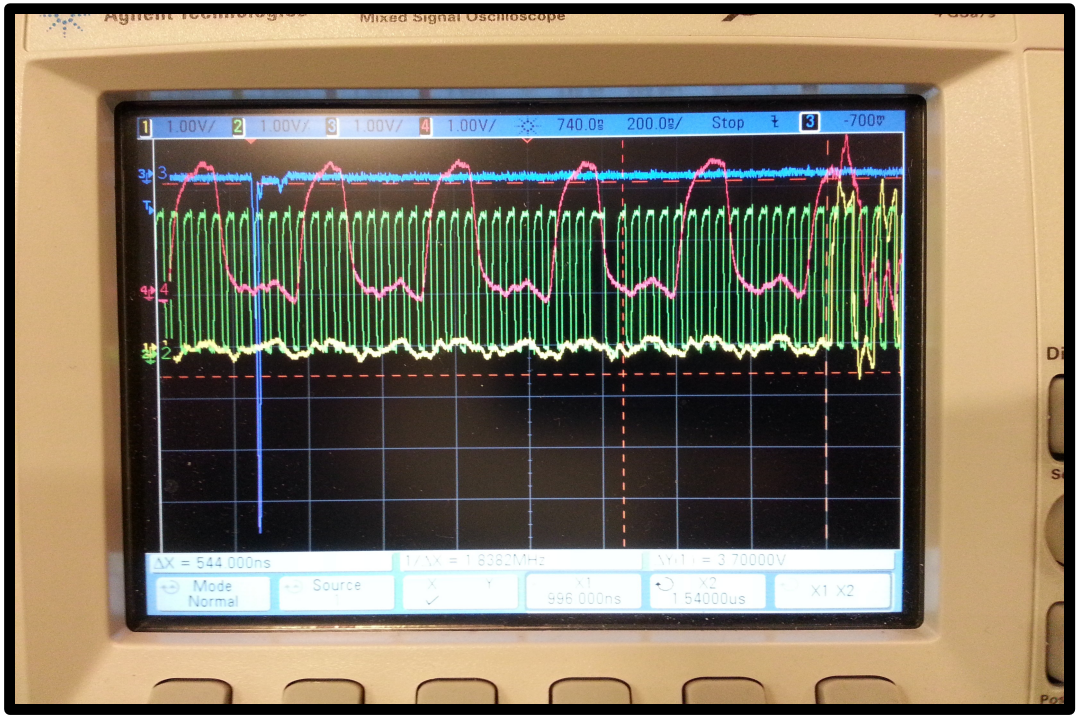


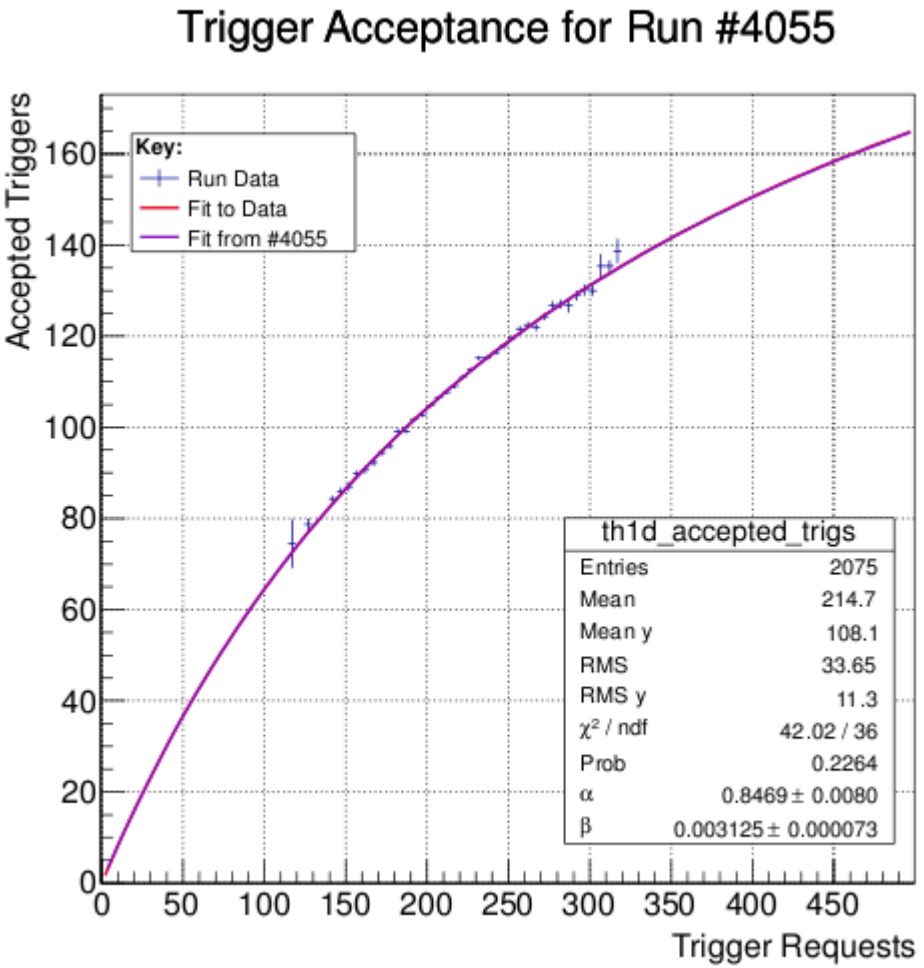




- Routing of waveguides through PRY will prove challenging
- Mock-up shows it is possible in principle

- Serial ADC digitization generates a 5.7 microsecond dead time which is the primary dead time of MICE
- Action from MPB to increase data-rate as much as possible
- May involve discarding analogue and time information from the trackers



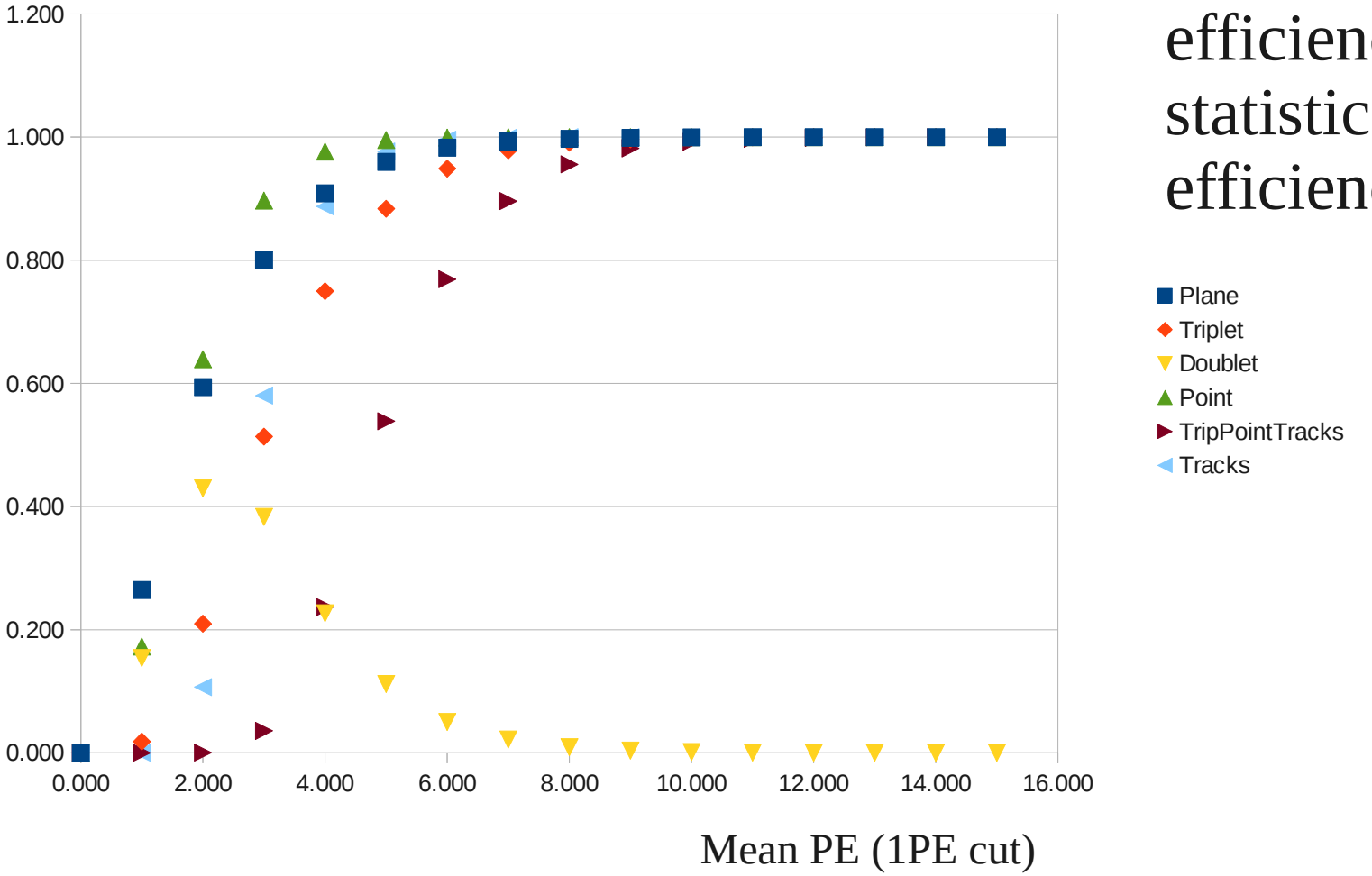


Summary

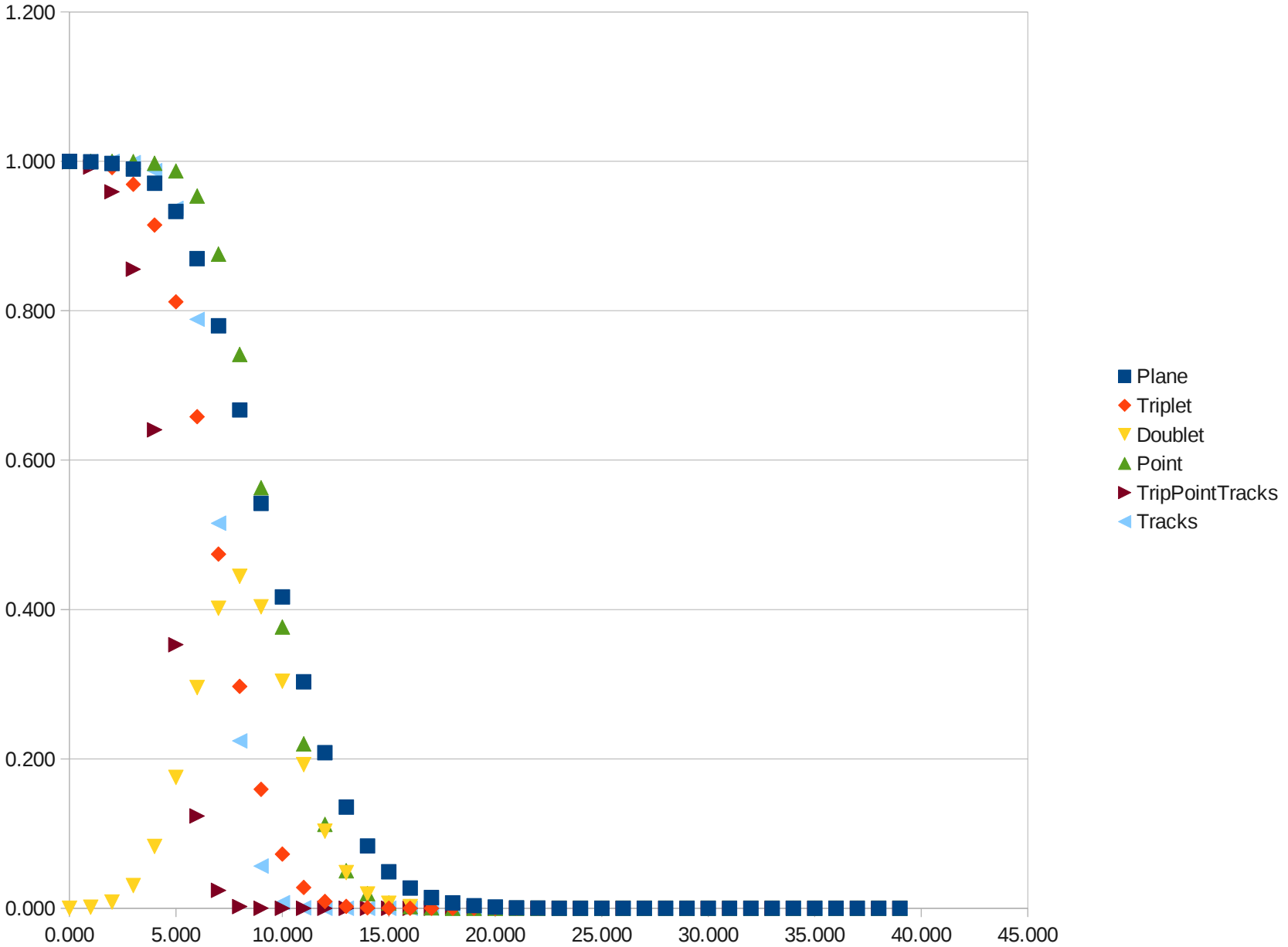
- Construction and installation is complete
- Issues with temperature from November look solved with purge/compressor move
- Final integration and commissioning in the first half of 2015
- Tracker must move from “working” to “precision” detector in the MICE environment (RF timig, local noise, global detector framwork)
- Requires detailed understanding of position and tracking within the magnetic field

Backup

- First consider uniform efficiency and statistical behavior of efficiency



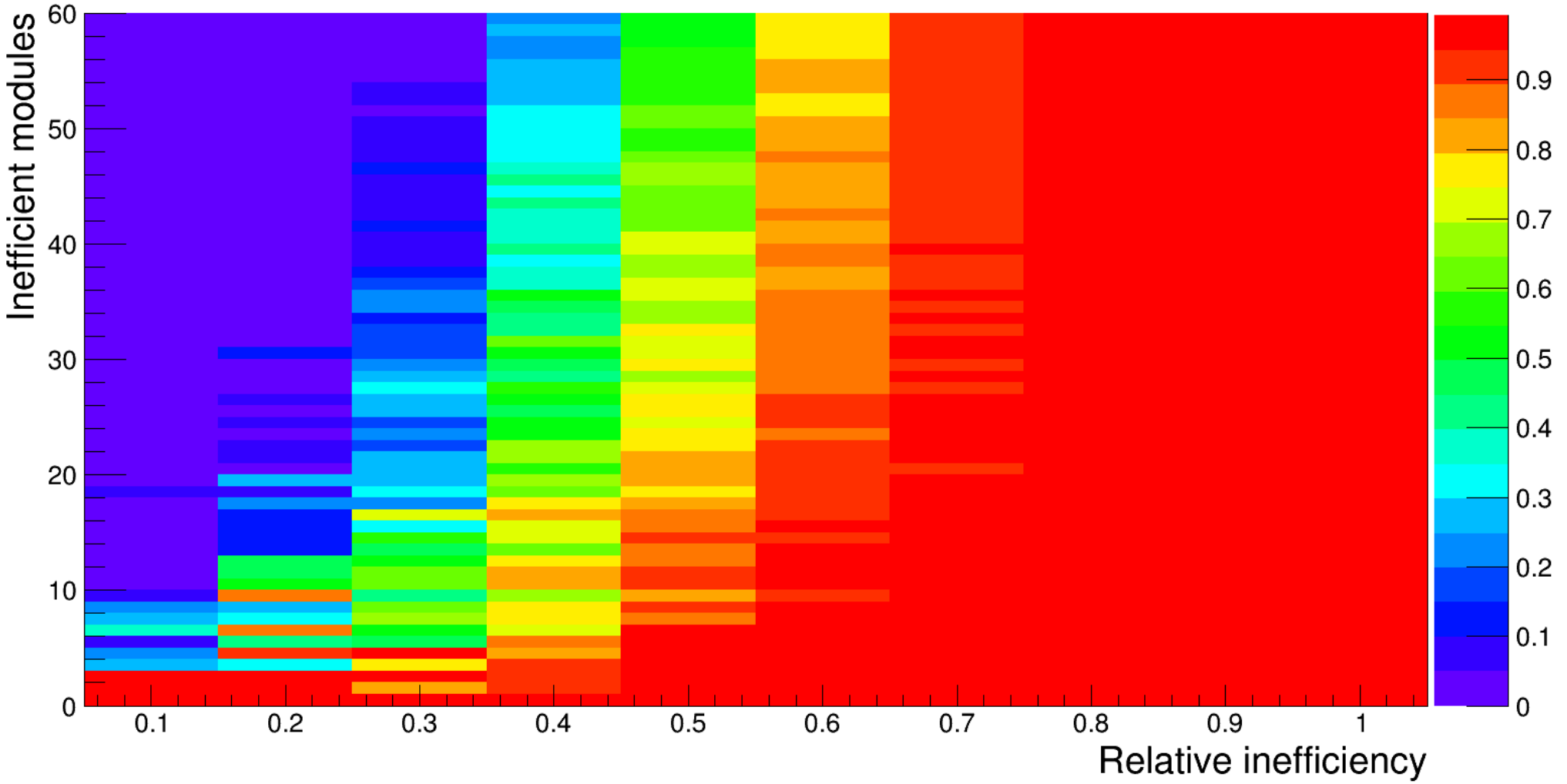
- Assumes binomial hit efficiency (OK)
- Poisson light yield (Not OK) - Saying “10PE mean light yield gives 99.9% plane efficiency” is not correct
- Re-treat as binomial problem with high k,n,p?
- Re-evaluate linear ADC-PE conversion to accommodate gain dispersion? Dispersion is an issue when cut is made at mean ADC of 1PE peak



PE Cut with 10PE mean

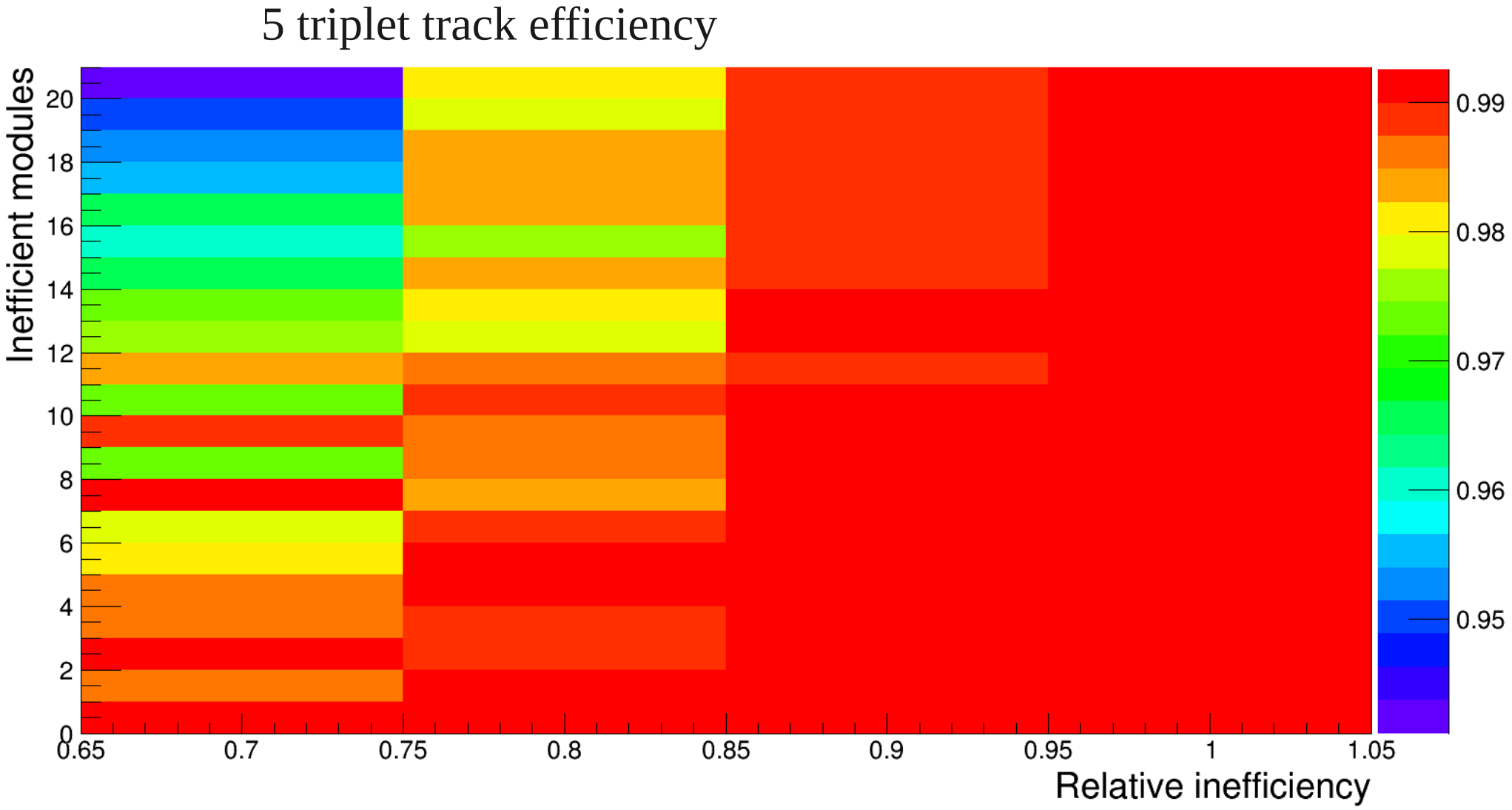
- Next consider non-uniform efficiency and statistical behavior of efficiency

Efficiency of 5 triplet tracks with N modules at X efficiency

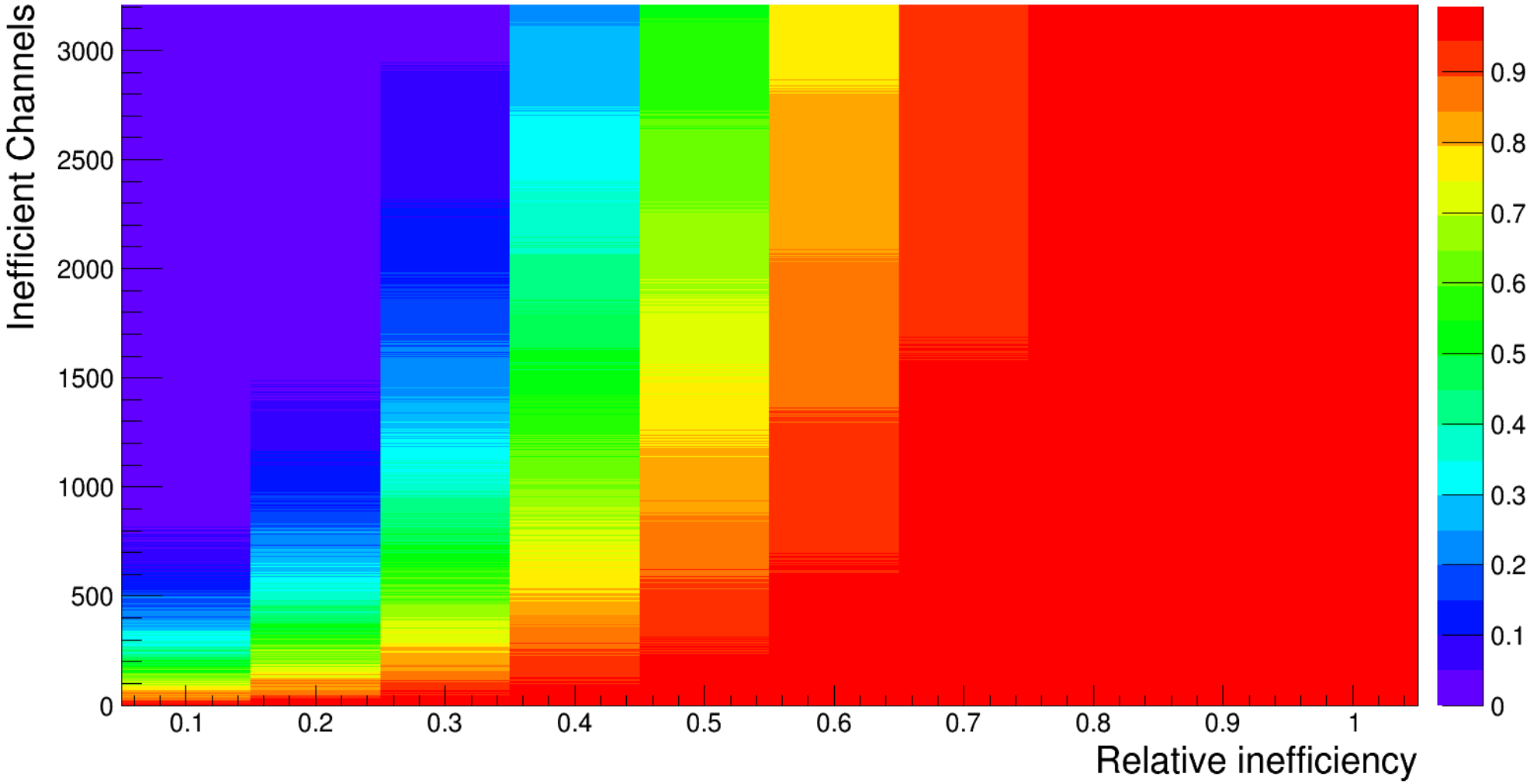


Can tolerate:

- Fewer than 10 modules at 90%
- Fewer than 5 modules at 80%
- Maybe 1 module below 70%



Efficiency of 5 triplet tracks with N channels at X efficiency

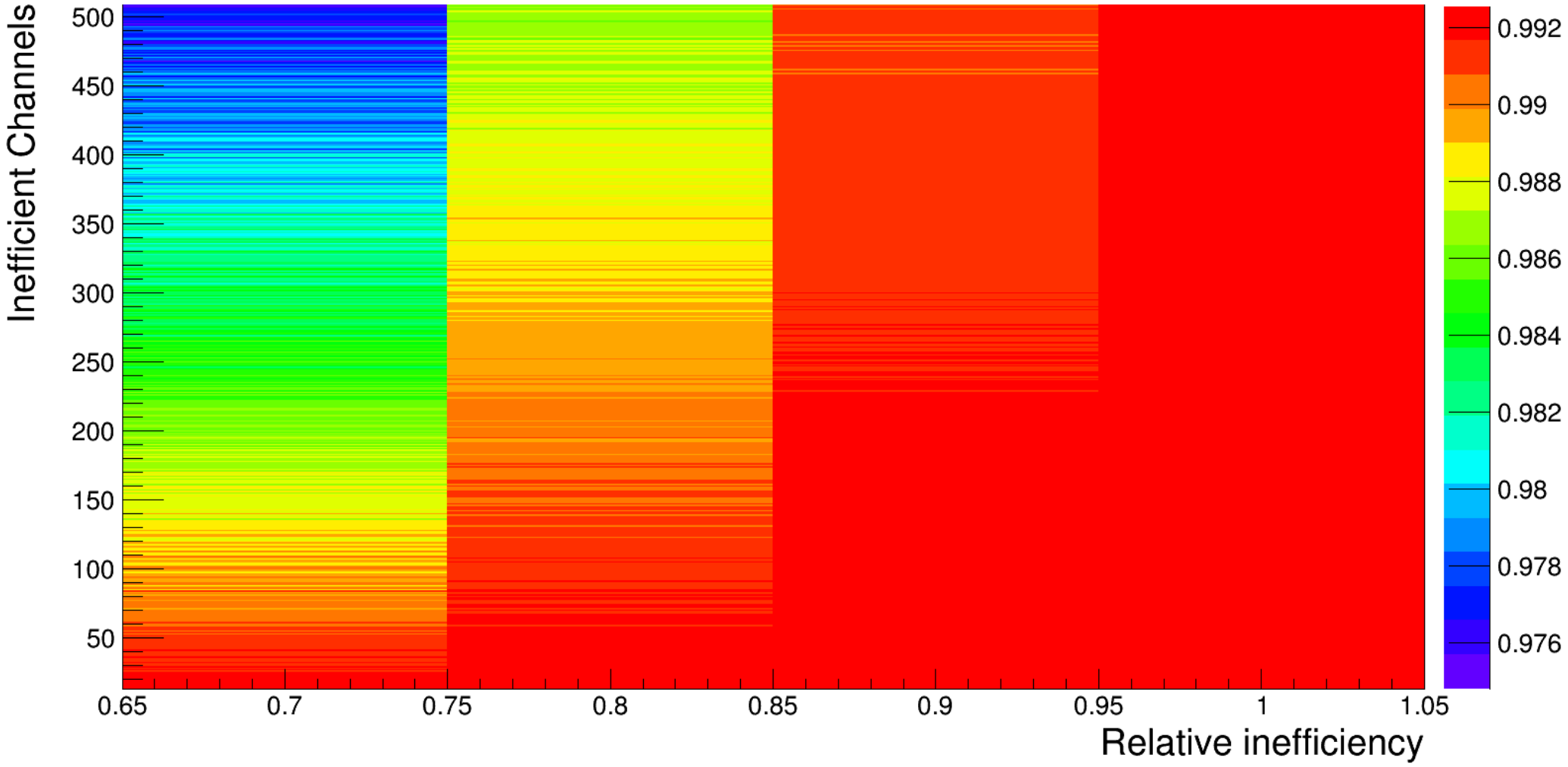


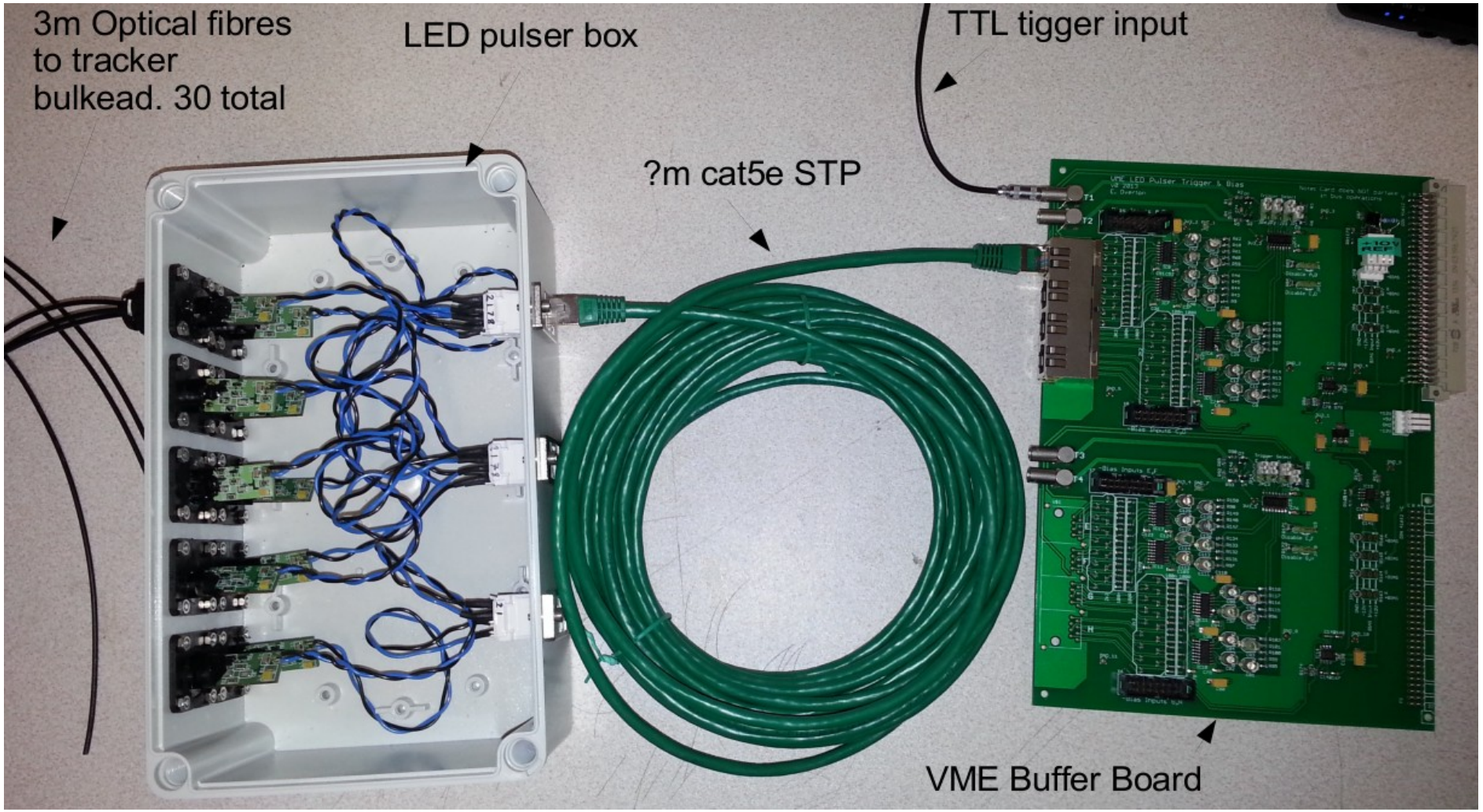
Can tolerate:

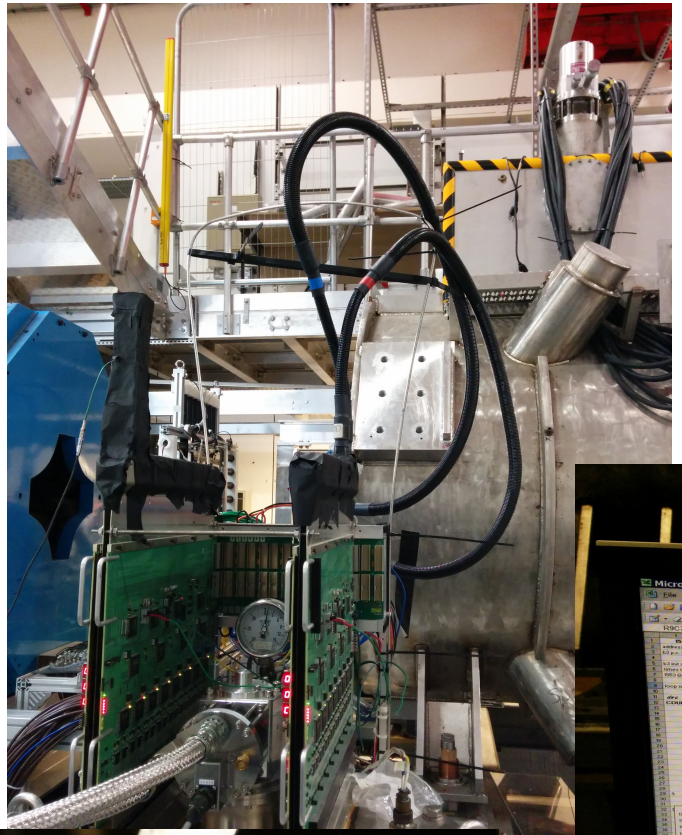
- Fewer than 800 channels at 90%
- Fewer than 200 channels at 80%
- Fewer than 100 channels at 70%

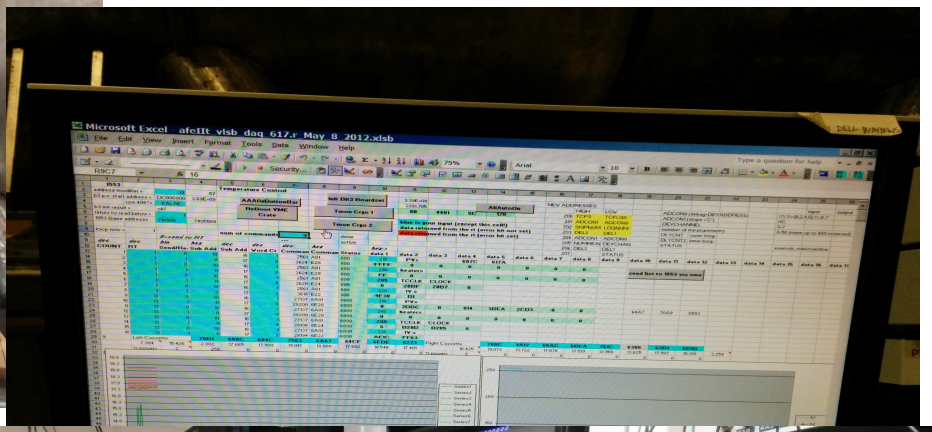
But, without correlations to desired observables, could just take more data

5 triplet track efficiency




3m Optical fibres
to tracker
bulkead. 30 total
LED pulser box
TTL tigger input
?m cat5e STP
VME Buffer Board




Microsoft Excel - afeIIt_vlsb_daq_617.r May 8 2012.xlsb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971